BUILD THE TIMBERWOLF DELTA TRIKE

Another Atomic Zombie™ Extreme Machines Adventure

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ABOUT THE TIMBERWOLF RECUMBENT TRIKE

The TimberWolf combines the agile and speedy characteristics of a racing trike, along with the comfort and practicality of a shopping trike to bring you the best of both worlds. Having a seat height of around 16 inches gives the TimberWolf a good stance for city traffic, yet allows for some very agile handling characteristics with the ability to take corners at a much higher speed than what would be possible on an upright delta trike. The TimberWolf also includes rear suspension with a cargo area behind the pilot's seat, so that the pilot can carry fragile objects safely.

Almost all of the components needed to build the TimberWolf can be purchased as inexpensive common bicycle parts at just about any bike shop and the main frame is made out of standard mild steel tubing. The rear wheels are also standard bicycle rims laced around a set of easy-to-make hubs that cost only a few dollars to build, so you will not need to spend a lot of money on specialized or difficult to find rear wheels or parts. The completed TimberWolf's rear wheels and axle sets are actually lighter and stronger than what can normally be found on most of expensive production delta trikes. This means that heavier loads can be carried without compromising stability.

This plan will take you through every step of the build process with detailed photos, using methods of construction that allow for alternate parts or design ideas to be used, according to individual preferences. However, please read the entire plan before purchasing any materials so that you can decide if you want to modify the design, or use alternative components you may already have on hand. There is no strict "materials list" or "cut list" provided.

Once you read the plan over before starting your build, you will notice that all of the materials and components needed are discussed throughout the document. But, don't be afraid to try your own design modifications as there is plenty of room to alter the plan along the way. If you are unsure about an idea, drop by our Builder's Forum and toss out your idea for discussion.

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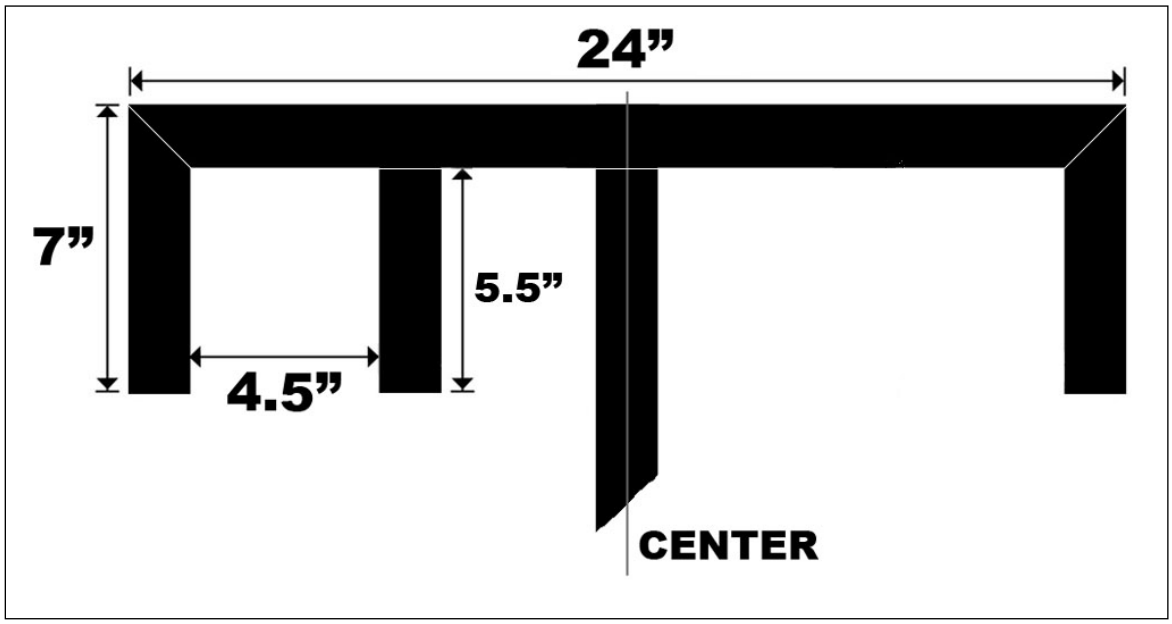
REAR FRAME



Drawing 1 – The rear of the TimberWolf frame

Most of the TimberWolf frame is made from 1.5 inch mild steel square tubing with a 1/16 inch wall thickness. This tubing can be ordered from any steel supplier and is very easy to cut and weld. Steel suppliers like to rate tubing wall thickness using a gauge number, so 1/16 wall tubing will be called 16 gage tubing. Although there is a slight difference between the two, your best bet is to tell them you want a length of 1.5 inch square tubing with a wall thickness as close to .0625 inch (1/16) as you can get. If you are a heavy rider (over 300 pounds), then you should ask for the next size after that, which will most likely be 14 gage tubing, or .078 inch wall tubing. Round tubing should be avoided for this project, as it will yield a very flexible frame which will most likely be out of alignment after all the welding is completed. If you have not read the entire plan yet, please do so before ordering any tubing as the process of building the frame will explain the entire length of tubing needed, which can vary depending on your leg length and possible design modifications. Tubing often comes in fairly long lengths, and it may actually cost you less to purchase an entire 20 foot length, which will come in handy if bike building is to be a long time hobby.

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Drawing 1 shows what I will refer to as the rear of the TimberWolf frame. It is made from the same 1.5 inch square, 16 gage (or 1/16 inch wall thickness) tubing that will make up the entire main frame. This part of the frame will determine the overall width of the final trike, and it can be widened for larger riders, if necessary. As you can see, the overall width of the rear frame is 24 inches, which will be fine for most riders. If you are a larger rider and plan to hit corners at full speed or add a powerful hubmotor, you may want to consider making your frame a little wider for stability. A 24 inch wide trike handles very well, does not "hog" the bike path, and can easily be moved through doorways, but a larger width may be difficult to move through a doorway or up stairs kind. The wheels and hubs will add approximately 8 inches to the width of your completed trike, so a frame width of 24 inches means that the widest part of the trike will be 32 inches as measured across the end faces of each rear hub.

AXLE SUPPORT TUBES

Figure 1 – Cutting tubing for the rear frame

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The two outside tubes (refer back to Drawing 1) will carry the pillow block bearings and take most of the loading from the rear wheels. The tubes are called “axle support tubes”, and are cut to a total length of 7 inches, with a 45 degree cut at one end. Joining tubing at 45 degrees makes the joint stronger and also takes care of filling up any open tubing ends. If you make the 45 degree cut as shown in Figure 1, then you only need to make one 45 degree cut to get both of the outer axle support tubes. In other words, cut a 14 inch long tube in half using a 45 degree cut, and both tubes will be the same.

Figure 2 – Using a square to transfer the line around the tubing

A square with a 45 degree side as shown in Figure 2 is a necessary part of your toolbox. Once you have one line drawn, the other three lines around the tube can be easily drawn using a thin point black marker. I cut all of my tubing using a cutoff disc (zip disc) in my angle grinder, so it is important draw a line all the way around the tube. Using a hand held grinder can actually make more accurate angle cuts than a low budget cut-off saw if you take your time. Of course, there is certainly nothing wrong with a hacksaw, and if you take your time, handmade cuts can be extremely accurate.

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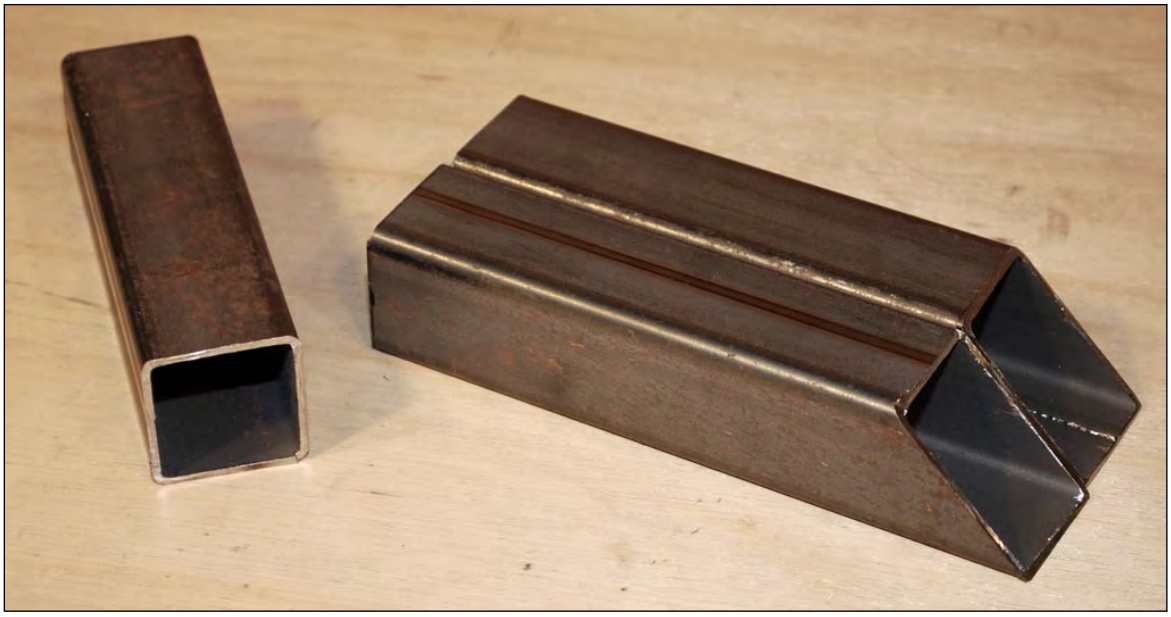

Figure 3 – Three axle support tubes cut

The third small axle support tube (shown on the left in Figure 3) is cut to a length of 5.5 inches, which is 1.5 inches less than the outer axle support tubes. This tube is not cut at 45 degrees, since it will be welded directly to the face of the rear frame tubing, which is why it is 1.5 inches shorter than the other tubes. The fourth axle support tube will actually be the main boom, and will be shown later in the plan.

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CAPPING ENDS

Figure 4 – Cutting end caps for the open tubes

There will be three open ended tubes at the rear of the frame that need to be capped. Capping off an open ended tube not only keeps moisture and critters out of the tubing, but gives the tubing greater strength and eliminates dangerous sharp edges. The axle support tubes will later have bolts through them, and the capped ends will help prevent the tubing from collapsing as the bolts are tightened. End caps can be made from any similar thickness flat bar or cut directly from some scrap 1.5 inch tubing. Figure 4 shows the three end caps I made from some scrap 1.5 inch tubing.

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Figure 5 – Welding the end caps

The end caps are welded all the way around the joints as shown in Figure 5. It is much easier to weld on the end caps before the axle support tubes are welded to the frame, as you can easily work with the parts on your workbench. Use a generous bead of weld to seal the entire joint, and turn down your amps a little to avoid a burn through. These welds are mainly cosmetic and will be completely ground smooth later.

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Figure 6 – Cleaning up the end cap joints

The completed end caps are shown in Figure 6 after cleaning up the joints with a sanding disc (flap disc). A flap disc is a special grinder disc containing multiple flaps of sandpaper, and it does wonders for cleaning up welded joints, bicycle frame stickers, and even paint. Work the bulk of the weld metal away with a standard grinder disc and then finish the final cleanup using the sanding disc to end up with that smooth seamless look shown in Figure 6. When grinding a weld flush, ensure that you don't grind lower than the original metal or the joint will be weakened. For the end caps, this is not much of a concern as they are not under stress.

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TUBING ALIGNMENT

Figure 7 – The rear frame tube and two axle support tubes

Referring back to Drawing 1, the rear frame tube is a 24 inch long piece of 1.5 inch square tubing cut at 45 degrees on both ends to form a 90 degree joint with the two outer axle support tubes. Figure 7 shows how these three parts will fit together. When laying out tubing for welding, place all tubes on a perfectly flat surface so that they will stay in alignment when being tack welded. If you do not have a good flat surface to work on, a piece of ¾ inch thick plywood would even work, just make sure it is not warped.

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Figure 8 – Using a square to align the tubing

As shown in Figure 8, the 90 degree square is again used to ensure that the angle between the axle support tubes and rear frame tube is good while applying a solid tack weld in the center of the joint. A small bit of distortion will occur when welding the frame joints, but this has been accounted for and addressed later in the plan, but do your best to get the 90 degree angles as close as you can when tack welding the parts together.

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Figure 9 – Setting the 90 degree angles

With only a single tack weld holding the tubing together as shown in Figure 9, it is very easy to tap the parts with a hammer if the angles need to be “coaxed” into alignment. When you have the 90 degree angles set perfectly, add a few more tack welds at the corners of the joint to secure the parts in place. Re-check and repeat, if necessary. Break the joint and try again if you find the alignment to be obviously skewed after tack welding.

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WELDING JOINTS

Figure 10 – Welding order is important here

When welding a joint, it is important to think ahead and complete the welding in the order that will help reduce distortion between the two parts. When a welded area cools, there is a very strong contraction force that can easily pull the parts out of alignment if they are not held securely. A frame jig is often used when many parts will be made, but for a single frame, the cost of such a rig would be not worth the effort and probably take more time to build then the entire trike! There are however, a few simple tricks you can use to keep heat distortion to an absolute minimum.

The inside corner of a joint should always be done last, as it will cause the most distortion. An outside corner will cause the least amount of distortion, and the top of a joint will generally not cause much distortion. Knowing this, it is easy to conclude that the outside corner of the joint between the axle support tubes and rear tube should be done first, followed by the top and bottom of the joint. Figure 10 shows the welding

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completed by first welding the outside corner and then the top and bottom side of the joint.

Figure 11 – Weld the inside corner last

The inside corners of the joint (Figure 11) are done last with as light a bead as you can lay down to keep heat distortion to a minimum. There will be a bit of distortion and warping along the rear tube, but don't worry, this will not affect the rear axle alignment, due to the way things will be done later. In other words, a slight bowing of the frame here will not affect the parallel tracking of the wheels due to the way this project will progress from here.

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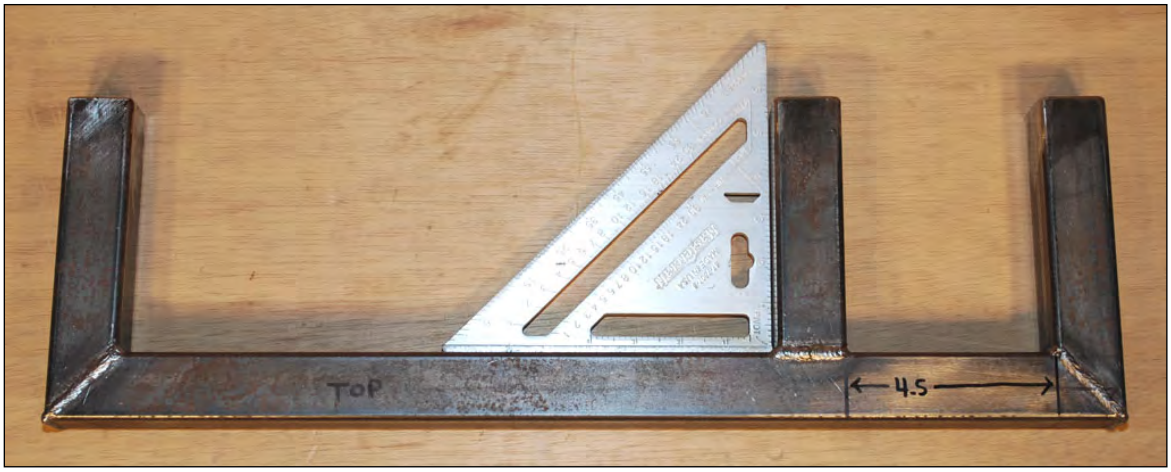

Figure 12 – Installing the last small tube

The last small axle support tube is welded in place as shown in Figure 12 so that there is a 4.5 inch distance between it and the outer axle support tube. This small axle tube will be on the right side of the frame, and it carries the non drive wheel (right side wheel and axle). Again, keep in mind the order of welding operations to minimize heat distortion.

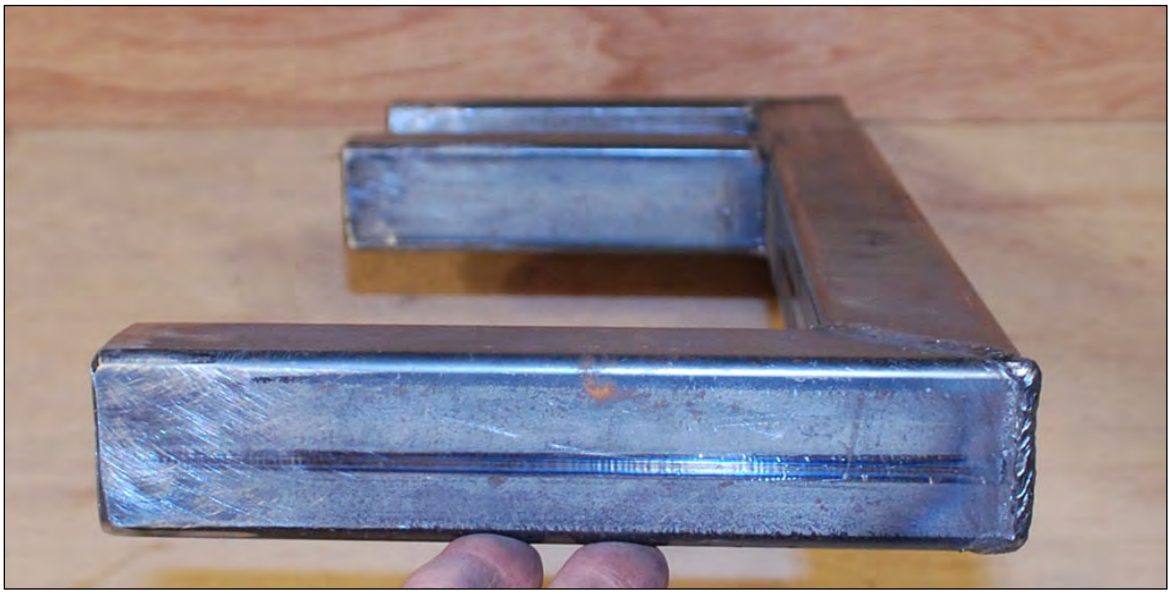

Figure 13 – Checking alignment

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There may be a very slight amount of misalignment between all of the axle support tubes as viewed from the end (Figure 13), but it will be very minimal, as long as the surface you were welding on was flat. Misalignments here will cause slight leaning of your rear wheels, but will not have any effect on handling, and will not be noticeable unless the frame is badly warped.

Figure 14 – The inside joints are done last

The inside joints of the small axle support tube will be the last to be done, following the usual order of welding operations. Figure 14 shows the three axle support tubes welded to the rear frame tube, completing most of the rear frame assembly.

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MAIN REAR BOOM TUBE

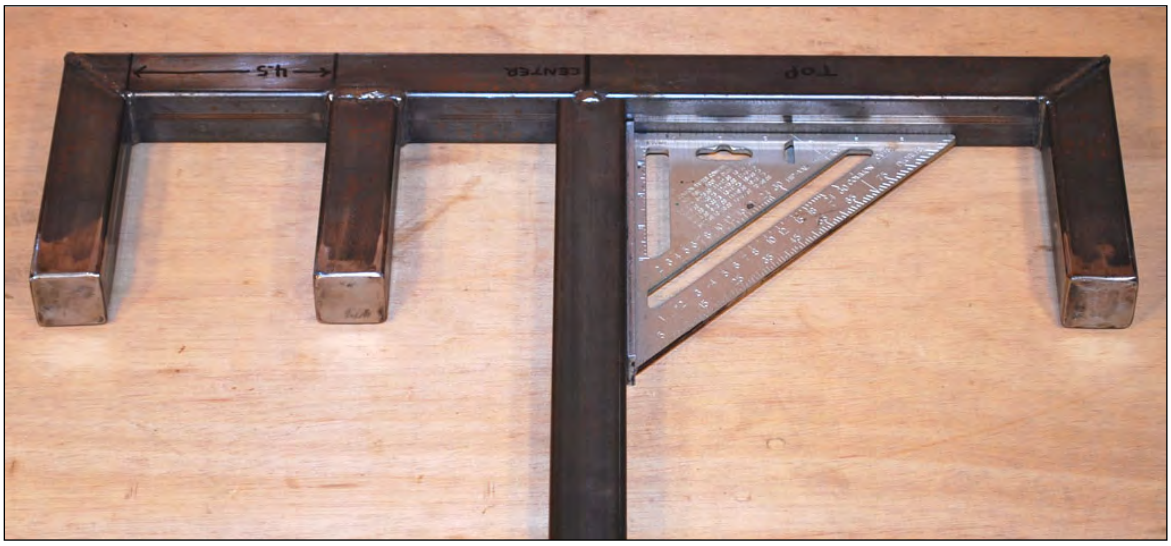

Figure 15 – Installing the main rear boom tube

The main rear boom tube connects the rear frame to suspension pivot point and it will become the fourth axle support tube. The rear main boom tube is welded directly to the center of the rear frame as shown in Figure 15 so that it forms a 90 degree angle between it and the rear frame tube.

The length of this tube will be 14.5 inches, and it is cut at 90 degrees on both ends. Later on in the build process, the open end of the 14.5 inch long main rear boom tube will be fish-mouthed to allow for installation of the suspension pivot tube, but at this point we need to create the rest of the rear, including the wheels so that the front of the trike can be built based on your choice of rims and tires.

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Figure 16 – Welding the main boom

When welding the main rear boom tube to the rear frame tubing, remember that the welds on the underside of the rear frame tubing will prevent you from placing the boom on the same flat surface as the rear frame parts. You will need to place a small object or cardboard under the main boom tube to bring it up to the height of the rear frame assemble so it can be tack welded in place. When installed, all four tubes should be perfectly in line when viewed from the side as shown back in Figure 13. Figure 16 shows the top of the main rear boom welded after checking for the 90 degree angle between it and the rear frame tube.

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Figure 17 – Rear frame welding completed

The inside corners of the 14.5 inch long main rear boom tube are the last welds to be made on the rear of the frame. Figure 17 shows the installed main rear boom tube, which will also become the fourth and last axle support tube.

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AXLE MOUNTS AND PILLOW BLOCK BEARINGS

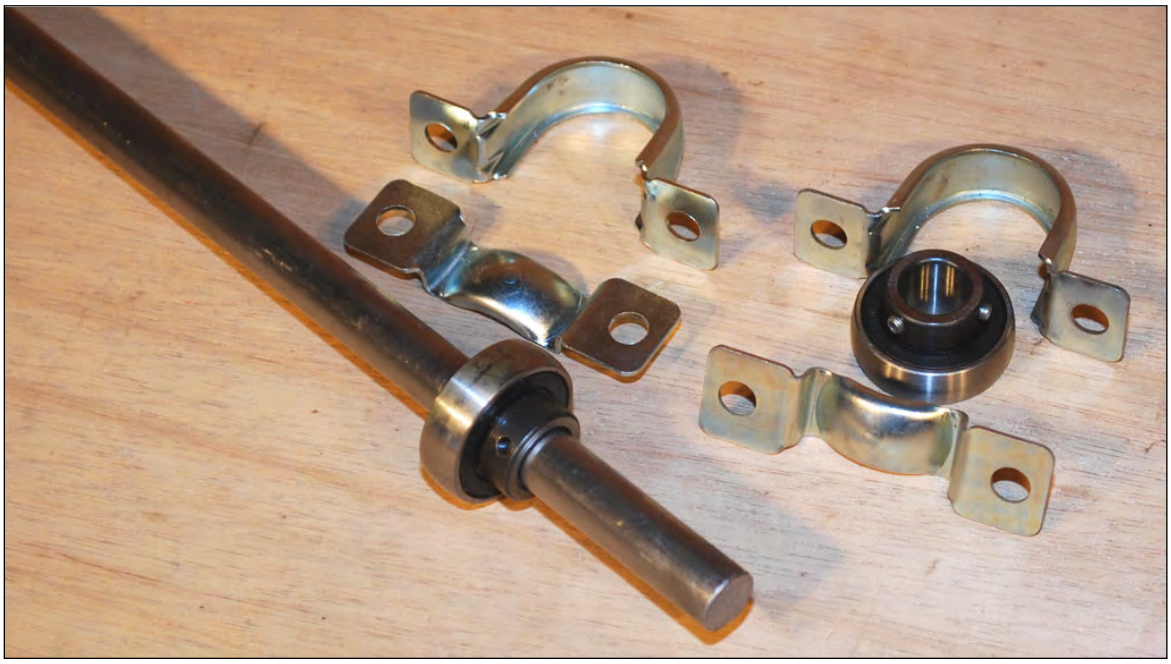

Figure 18 – The 5/8 axle and matching bearings

The TimberWolf has two separate rear axles, which makes sense considering that only one wheel drives and the other one brakes. These axles are made from non-hardened cold rolled steel with a diameter of 5/8". It is important to ask for "cold rolled non-hardened rod" when sourcing the axles since hot rolled steel will not be round enough to properly install the bearings, and hardened steel could cause the axle to break where it will be welded. You will need a total axle length of 3 feet, or 12 inches more than the width of your frame. Some of this axle length will be cut later on, but it is important in the wheel alignment process, which will soon be shown. Always best to have a little more than necessary then end up a little too short!

Along with the 5/8 diameter, 3 foot length of cold rolled steel axle, you will also need 4 pillow block bearings with a 5/8 inside diameter as shown in Figure 18. These bearings are available with either pressed steel bodies as shown in Figure 18, or with larger cast iron bodies. Both types will work fine, but the cast iron units do weigh a bit

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more and may cost you a few dollars more. If you are a large rider, or plan to experiment with a rear motor drive, purchase the cast iron pillow block bearings.

If you are wondering why the axle isn't simply left as a single length similar to a go-cart with two wheel drive, let me explain why this would not work. If the rear wheels were tied to a single axle, one wheel would have to drag along when the trike turns a corner, since the outer wheel is traveling faster than the inner wheel on a corner. This drag is not a problem in a racing go-cart due to the frame twisting and inside wheel slightly lifting as the vehicle makes the corner, and the result may be better grip and less steering twitch.

However, on a human powered trike like the TimberWolf, this would not be the same. The wheel drag would either slow you to a stop, or cause the front wheel to skid along in a straight line no matter how much you tried to corner. Even if you could somehow overcome the wheel drag friction (unlikely), and force the trike to corner, you would probably rip the spokes out of the rim due to the force imposed on the rear wheels. The simple fact is that a trike or quad cycle will never function with a straight axle between the rear wheels, and none are made that way. There is a special gear unit for trikes called a “rear differential” to give two wheel drive, but such a unit will cost you much more than this entire project, add 20 or more pounds to the weight of the bike, and limit you to a low quality rear brake. Almost all production delta trikes are single wheel drive as well.

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Figure 19 – Marking the bearing body holes

The pillow block bearings are mounted at the ends of the axle support tubes as shown in Figure 19, leaving about 1/8 inch around the end of the tubing. Ensure that both bearings (one at each end) are in the same position on the tubes and then use a black marker to mark through the bearing mounting holes onto the tubing. This is done on both sides of the tube since a hole needs to be drilled through the tubing for the bearing mounting bolts. The size of the hole to be drilled will be the same as the mounting hole in the bearings you purchased.

Note: Only the two outer bearings are mounted at this stage, so do not drill or mark the holes for the two inner bearings yet. Read ahead from here to Figure 27 as this will be explained.

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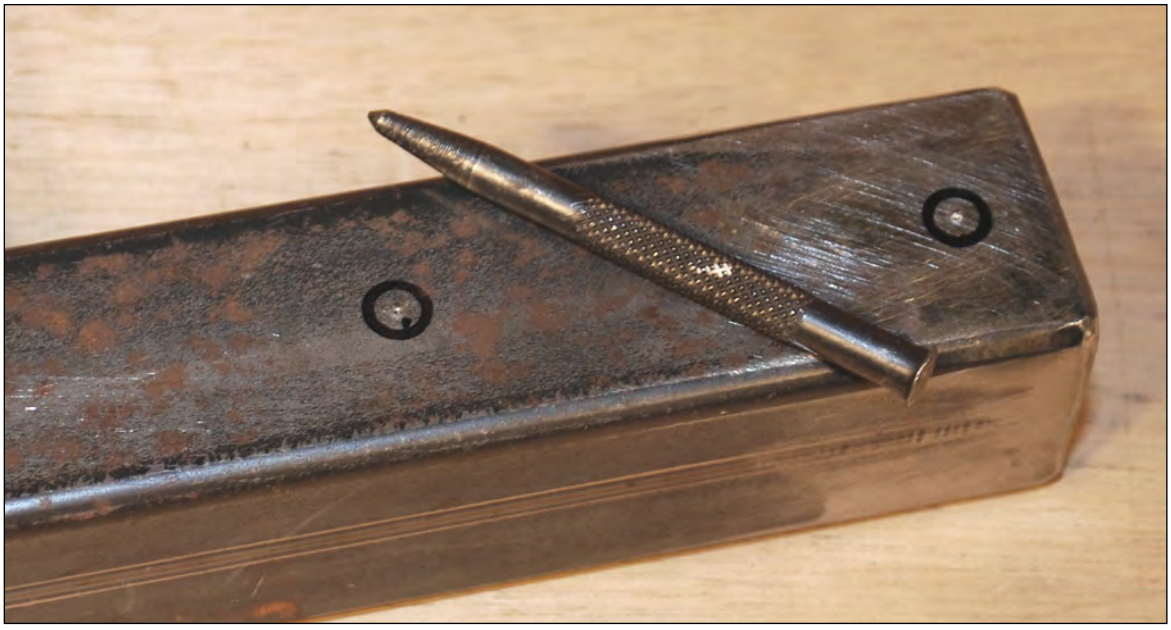

Figure 20 – Punching the drill holes

Use a center punch to punch a hole for drilling the bearing bolt holes. Figure 20 shows the punched areas ready to be drilled. Without a punch hole, drilling an accurate hole in the center of the circle is extremely difficult. The bearings allow for some misalignment, but do try to be as accurate as you can here.

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Figure 21 – Multiple bits make a hole more accurate

I do not own a drill press, so accurate hole drilling requires the use of several incremental bit sizes as shown in Figure 21. A step drill bit will also do this job, but these can be costly. Start with a 1/8 bit, and then work your way up to the desired diameter, skipping every second bit size. Drilling this way prevents the hole from wandering off the mark.

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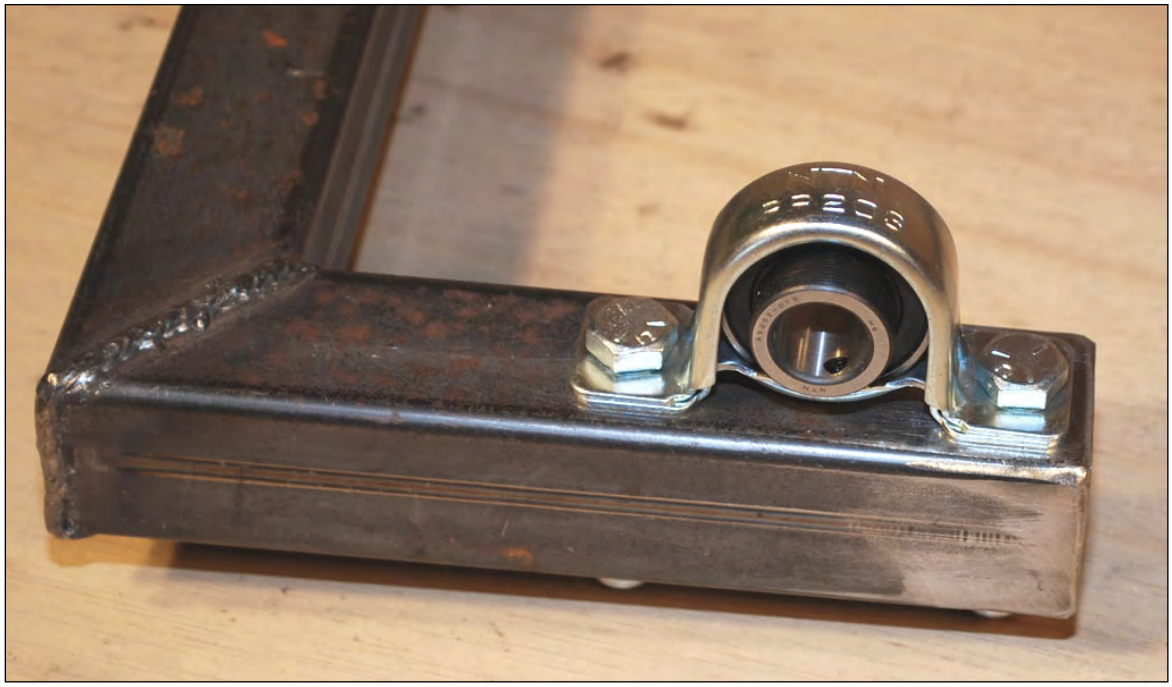

Figure 22 – Pillow block bearing bolted in place

The pillow block bearings will be bolted on the underside of the frame as shown in Figure 22 (the frame is upside down). By placing the bearing on the underside of the frame, the bearing bodies will be under very little stress, since all of the force will be transferred to the frame, not to the bearing bodies or bolts. The bearings are also protected from the rain this way, which is good if you plan to store your trike outdoors often.

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Figure 23 – Locknuts should be used here

To avoid the need to over tighten the bearing bolts, which could crush the tubing walls, use nylon locking nuts and washers so that the bolts won't come loose. Figure 21 shows the lock nuts and washers on the top of the frame. You only need to tighten the bearing bolts until they resist easy wrench effort, not so much that you are squashing the walls of the tubing.

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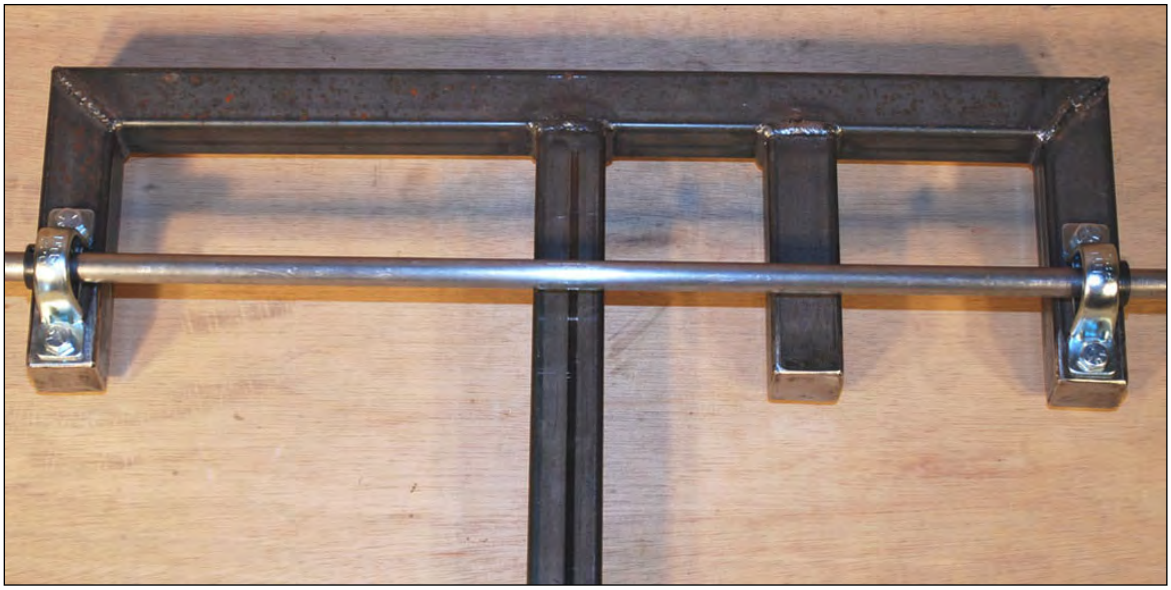

Figure 24 – Using the axle as a guide

It is important that the right and left axle be in perfect alignment to avoid a “toe-in” or “toe-out” wheel problem that would result in a loss of power and excessive tire wear. Since there will most likely be some distorting in the alignment of the axle support tubes due to the welding process, this error must be corrected during the axle installation process. The good news is that this job will be done for you by the two outer bearings that were just mounted. As shown in Figure 24, the single axle is installed between the two bearings, which will automatically find the perfect position for the other two bearings as shown in the next step. If the axle does not slide easily into the bearings, add a bit of oil, ensure that the bearing race setscrews are out, and check the axle end for burs or a mushroomed end.

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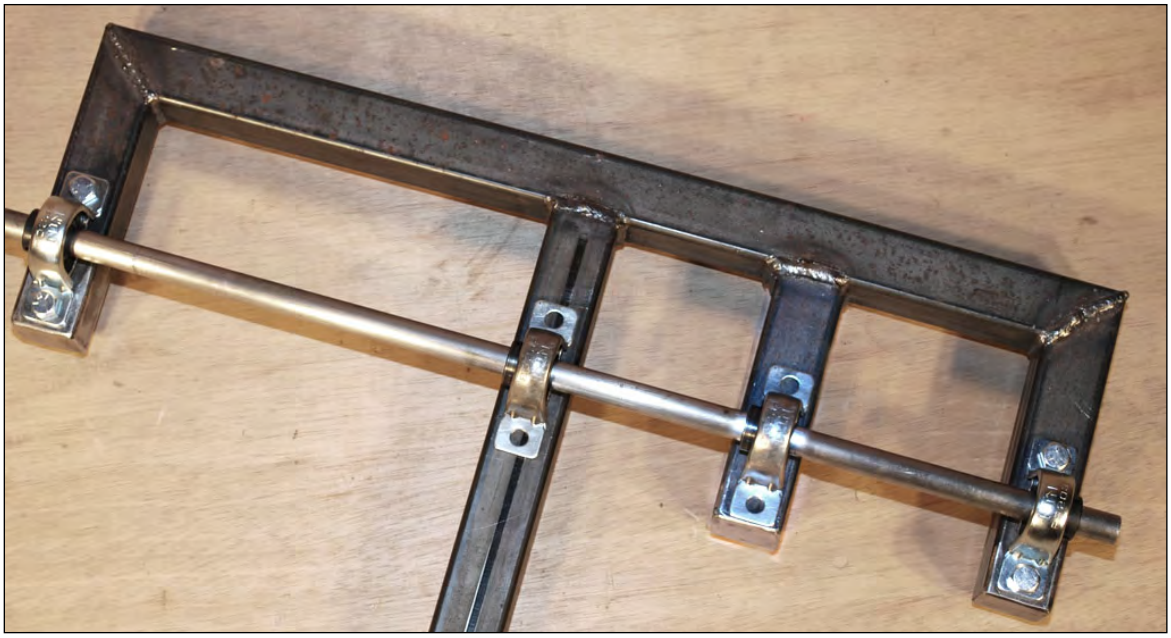

Figure 25 – Aligning the inner bearings

The two inner pillow block bearings will find their perfect alignment spot as shown in Figure 25 once the two outer bearings are bolted to the frame. You can now mark the holes to make the new drillings using the axle as a guide. Remember that this is done on both sides, so you will need to remove the outer bearings and bolt them on the other side to mark both sides.

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Figure 26 – Marking the axle for cutting

Once you have drilled the two inner bearing holes and mounted all of the bolts, slide the axle back in place and mark it as shown in Figure 26 for cutting. The axle should have equal material sticking out past the end bearings at each end, and the cut will be made between the two inner bearings. Also, the axle may seem difficult to slide into all four bearings once they are bolted down, so you may want to loosen the two inner bearings until the axle is in place and then tighten them back up.

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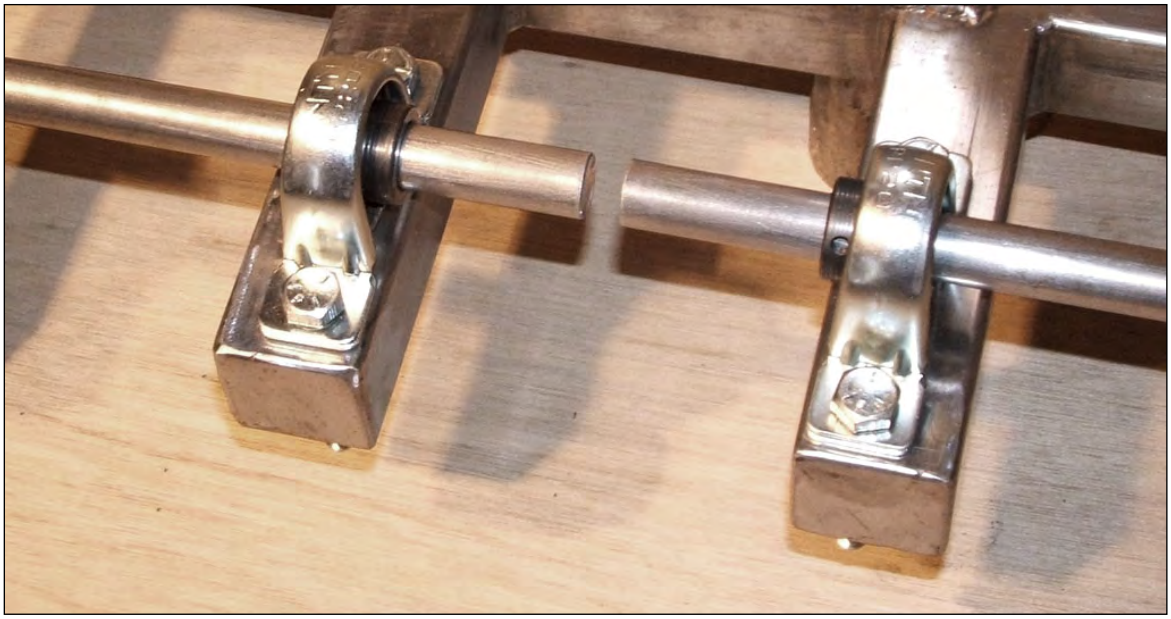

Figure 27 – The axle has been cut

I cut the axle using a zip disc by leaving the axle installed and tuning it while cutting. You could also remove it for cutting, but remember that the fresh cut end will need some filing or sanding to allow the bearings to easily slide off. A flap disc, hand file, or light sanding will remove the burred edge after cutting the axle material. Figure 27 shows the axle after cutting it in place with a zip disc.

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REAR WHEEL HUBS

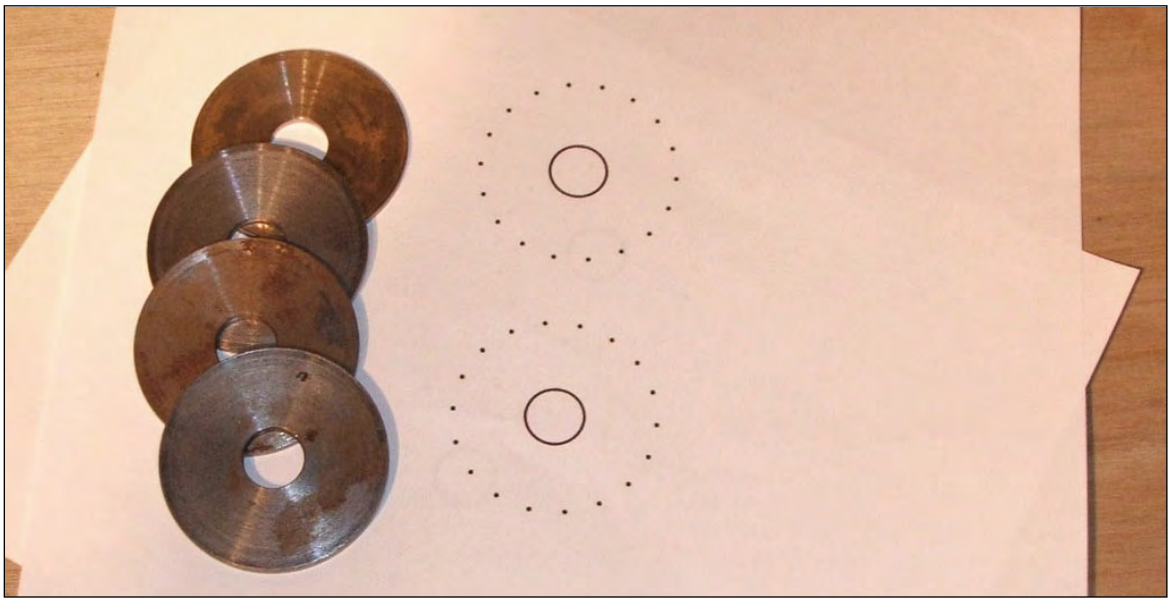

Figure 28 – These washer-like discs will become the rear hubs

One of the most unique features of the TimberWolf is that it has no rear hubs. The flanges that hold the spokes are actually part of the rear axles, so this greatly simplifies the design and saves the builder a lot of money that would otherwise go to purchasing expensive aluminum hubs to be custom machined. These simple DIY hubs also allow the hub flange distance to be made wider, allowing a 26 inch wheel to be used instead of a 20 inch. On a normal 26-inch rear wheel hub, the flanges are much closer together, so the wheel would not be able to withstand a great deal of side loading, and may tend to bend or collapse. Some commercial delta trike manufacturers compensate with extremely heavy rims and spokes or custom machined hubs. The wider the hub, the more lateral strength you put into the wheel, so this is how we are able to use a full sized 26-inch rear wheel on the TimberWolf rather than being forced into the smaller size. A smaller drive wheel means less top gear range and a much harsher ride, so this is a real plus.

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I came up with the hub/axle combination when I was working out how to build a delta trike without being forced to use 20-inch rear wheels. There were a few readymade options for good strong 36 spoke hubs, but not only were they very expensive, they were also designed for a 1 inch thick axle, way too much steel for a single rider trike. Those hubs were made for pedicabs (pedal rickshaws) and designed to carry two or more adults and the pilot, so that option wasn't useful. I thought about having a mountain bike hub drilled to fit the 5/8 axle I planned to use, but now I was into $150 per hub plus the time it would take to have them machined. Even after that the quest remained as to how to permanently affix the machined hubs to the axles - keyway? Ugly bolt or cotter pin? I thought there had to be a better way, and yes, there was.

Why use a hub at all? An expensive machined hub bolted to an axle does nothing at all - it is wasted material. All that was needed was the flanges to hold the spokes, and even if I made them from steel, they would still end up weighing less than a complete aluminum, alloy hub machined and fit to the axle. Since a hub flange was nothing more than a washer, this seemed like a really good idea. As shown in Figure 28, I had the machine shop slice off four 1/8 inch thick discs from a bit of 2.5 inch diameter steel stock and drill 5/8 inch holes through the center. The discs are actually slightly less than 2.5 inches in diameter, but anything close to 2.5 inches give or take 1/4 inch either way would be just fine. Although the four flanges only cost me $50 to have done at the machine shop, you could actually do this part without any machined parts at all using a pair of hacked steel bicycle hubs. I will show this method as well. Personally, I think the machined flanges are the best way to go, since they will result in a nice flat outer flange that does not look like a hacked bicycle hub, something that seems to plague many delta trikes. Read the entire axle/hub section that follows so you see how this is done before choosing which method to use.

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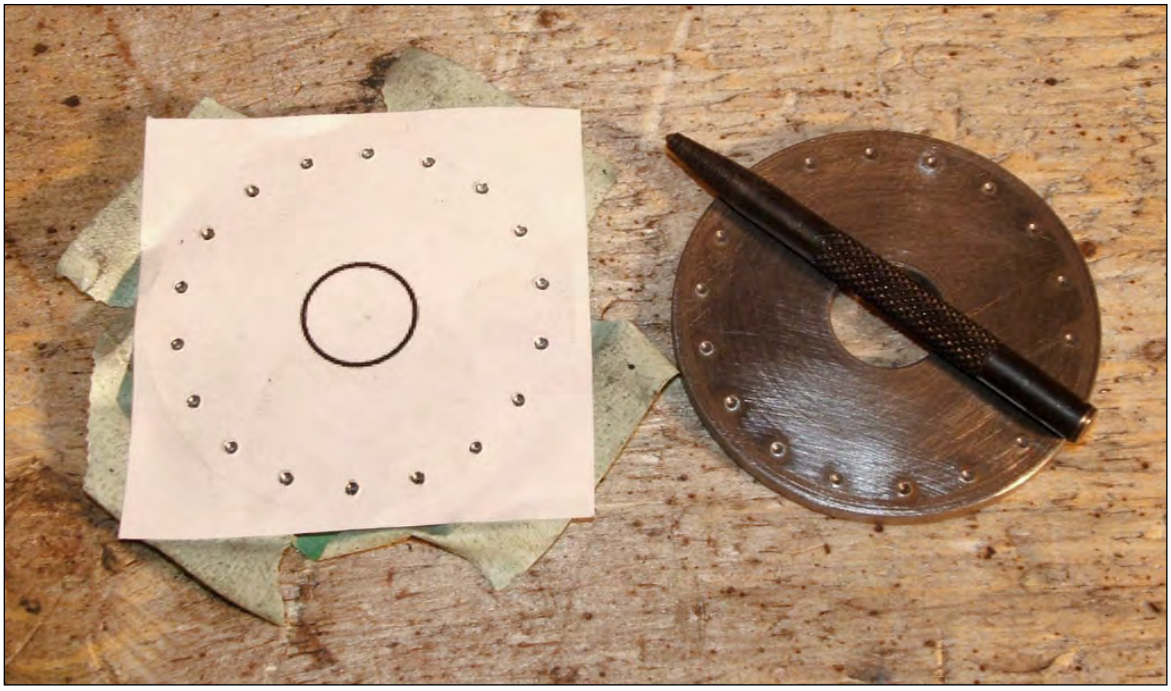

Figure 29 – Using a hub template

The four flange discs are made of mild steel 1/8 inch thick and approximately 2.5 inches in diameter. The hole in the center is 5/8 inch in diameter so that the discs will fit snugly onto the 5/8 axles used on the TimberWolf. If you decide to have these discs made at a machine shop, just print out this text and/or photo, or tell them you want four 2.5 inch diameter washers with a 5/8 hole in the center of each with a thickness of 1/8 inch. Also tell them that you plan to weld the discs, just in case they have some exotic or hardened steel. Mild steel is what you want.

The 18 spoke holes in each disc are drawn using a compass or by punching through a template as shown in Figure 29. There should be no less than 1/8 of an inch between the edge of the disc and the closest edge of the spoke hole to make the disc as strong as possible. In other words, the meat between the edge of the flange and the hole should be about the same diameter as the spoke hole. Have a look at how a normal bicycle hub is made, and you can see this. If you are not a compass expert or do not have a computer program that can make this template then you can download the image from our website at **http://www.atomiczombie.com/temp/dwhub.jpg** You can resize it in your favorite graphics program and print it out as a guide.

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You will need to resize the pattern by trial and error since all printers will print using different sizes, and the original file will likely be much too large. The circle drawn in the center of the pattern as shown in Figure 29 is used as a guide to tape the pattern onto the disc for punching. I hold the pattern and disc up to a bright light so the light shines through the pattern, allowing me to tape the pattern directly to the center of the disc. The resulting punched disc as shown on the right of Figure 29 is very accurate. If your machine shop buddy "owes you one", or you despise drilling holes, you could pay him or her to do this as well, but where's the fun in that?!

Figure 30 – Drilling the spoke holes

The spoke holes will be drilled using a 7/64 inch drill bit. It may seem like a lot of work to drill 72 small holes, but in reality, this entire job only takes about an hour depending on the quality of your drill and bits. I am a minimalist and do not own a drill press, so I do this work using a hand drill, which is why the disk is held to a board as shown in Figure 30 by a pair of wood screws. You could also bolt the disc to the end of

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your workbench so you can press into the disc while standing rather than trying to force the hand drill downwards.

Drill & turn, drill & turn, drill & turn. I am truly thankful that I do not manufacture bicycles for a living or this hobby would quickly turn into a real chore! My hand drill was getting a little warm by hole number 72, but I made it non-stop in less than an hour. If one of the spoke holes is slightly off center, don't fret, you will be able to adjust this during the wheel lacing process, and it will not affect the wheel.

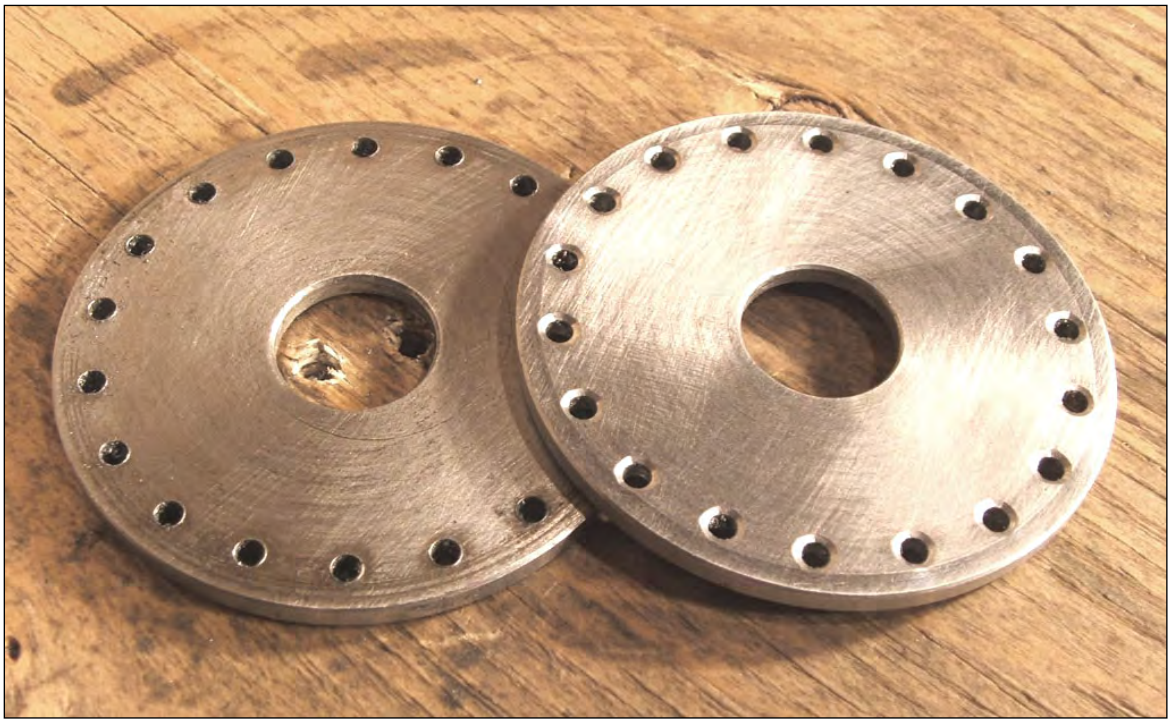

Figure 31 – Beveled spoke holes shown in the right

If you look closely at a standard bicycle hub, you will notice that the holes are very slightly beveled on the inside so that the spoke bend is not subjected to a very sharp edge as it exits the spoke hole. This process can be recreated by simply running a 1/8 inch drill bit lightly into each hole for about two seconds. The result will be a beveled hole like the one shown in Figure 31 on the right disc. Do not put any pressure on your drill when doing this operation, or you may drill into the hole, which is why a hand drill may be the best tool to use when doing this operation. The goal is to smooth off the

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sharp edge without making the hole any wider. Do this to both sides of all of the holes in each flange.

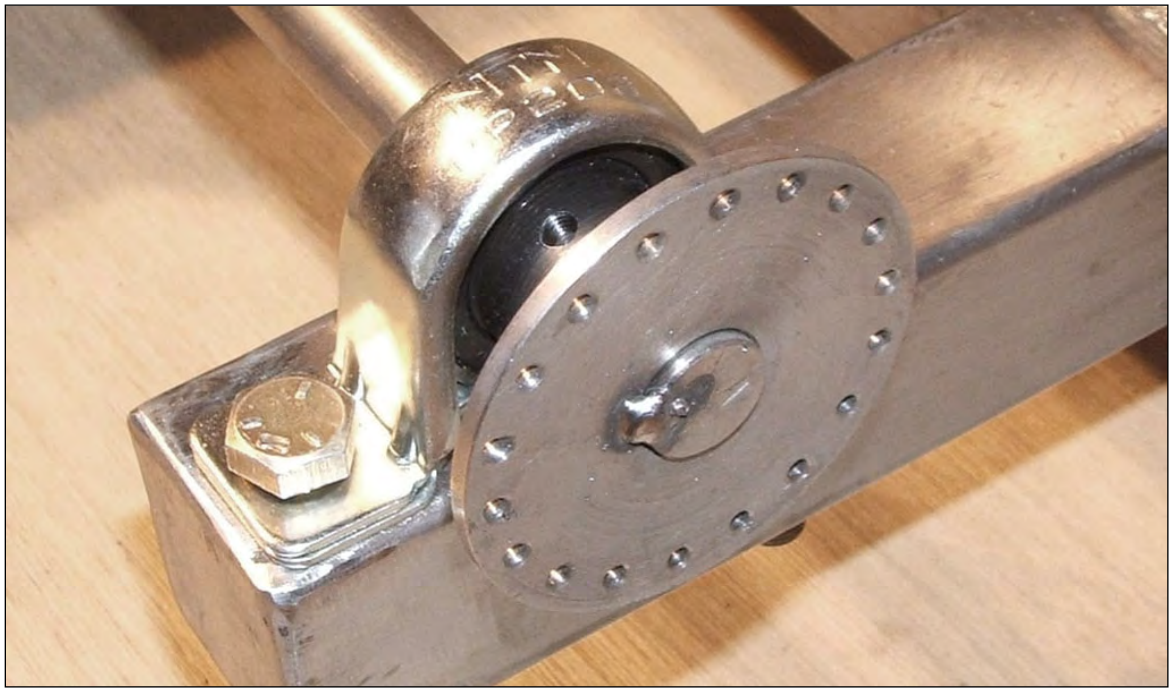

Figure 32 – Welding on the hub flanges

It's now time to integrate the flanges with the axle to create the axle/hub on both the drive and brake side (right and left) axles. As shown in Figure 32, this is done using the frame as a stand so that you can simply spin the axle in order to check flange alignment as you tack and weld. Before you make the first tack weld, it is important to note that you should never place your welding ground clamp in any place that would cause the current to flow through the bearing into the weld area.

If you clamped to the frame, the current would travel through the inner and outer bearing races and through the actual ball bearings in order to complete the circuit, which will damage the bearings. Since each ball bearing only contacts the inner and outer races by a very small surface area, the high welding current will create a pit in the bearing races, causing what would seem like years of wear on the bearing. Place the ground clamp on the axle, not the frame, and you will avoid this problem. Don’t clamp to the flange though, or the weight of the clamp and cable may pull the parts out of alignment as you weld. Place your ground clamp on the axle you are welding.

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Start with a small tack weld as shown in Figure 32, leaving about 1/16 of an inch of axle sticking out past the hub flange to make welding easier. Once the tack weld has cooled, remove the ground clamp and spin the axle to check alignment. It is very easy to see any misalignment of the flange as you turn the axle, and this is corrected using a few small taps of a hammer along the disc until it spins true. A very slight wobble is not a big deal in the end, since the spokes will correct this, but do try to get the disc spinning as true as you can while it is easy to manipulate.

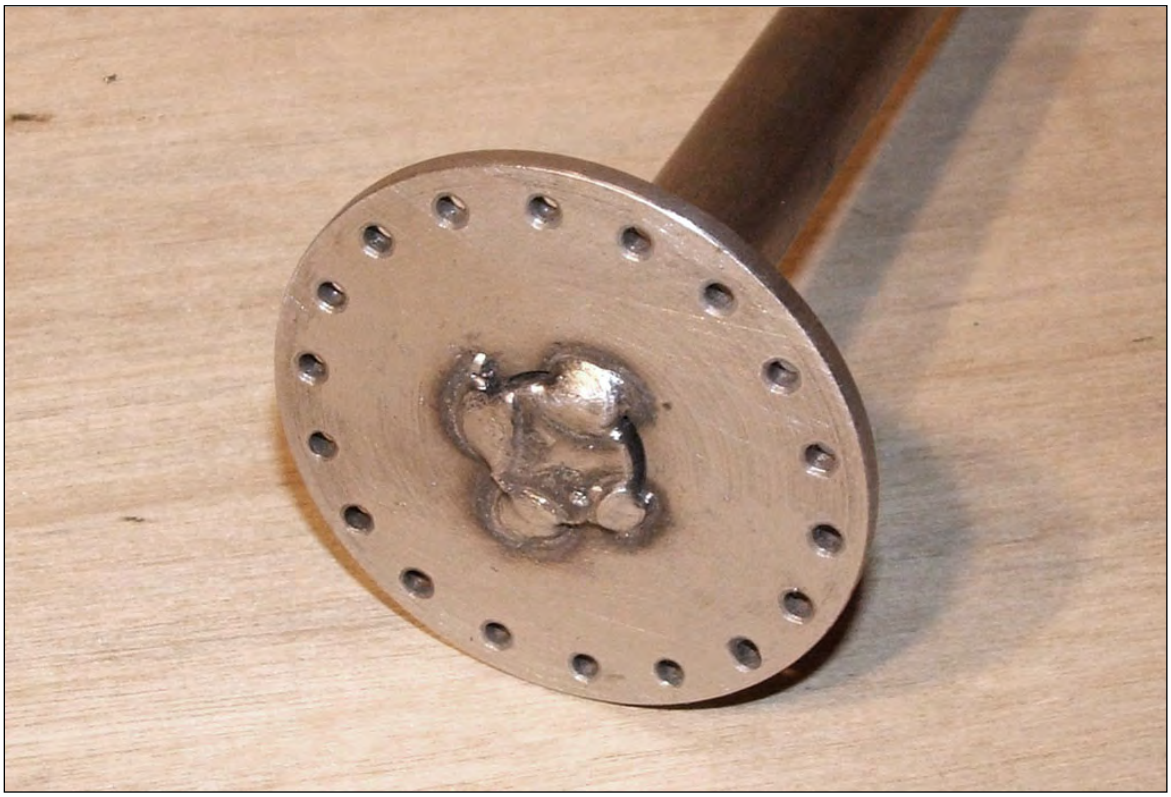

Figure 33 – More welds added to the flange

Once you have tapped the flange into alignment from the previous step, add another tack weld directly opposite of the first tack weld then repeat the spinning and tapping process to true the disc back up. Repeat this process until your hub flange looks like the one shown in Figure 33, with four decent tack welds holding the flange to the axle in as perfect alignment as you can get it. Once this is done, you can remove the axle and weld the opposite side joint with little fear of pulling the disc out of alignment with the axle.

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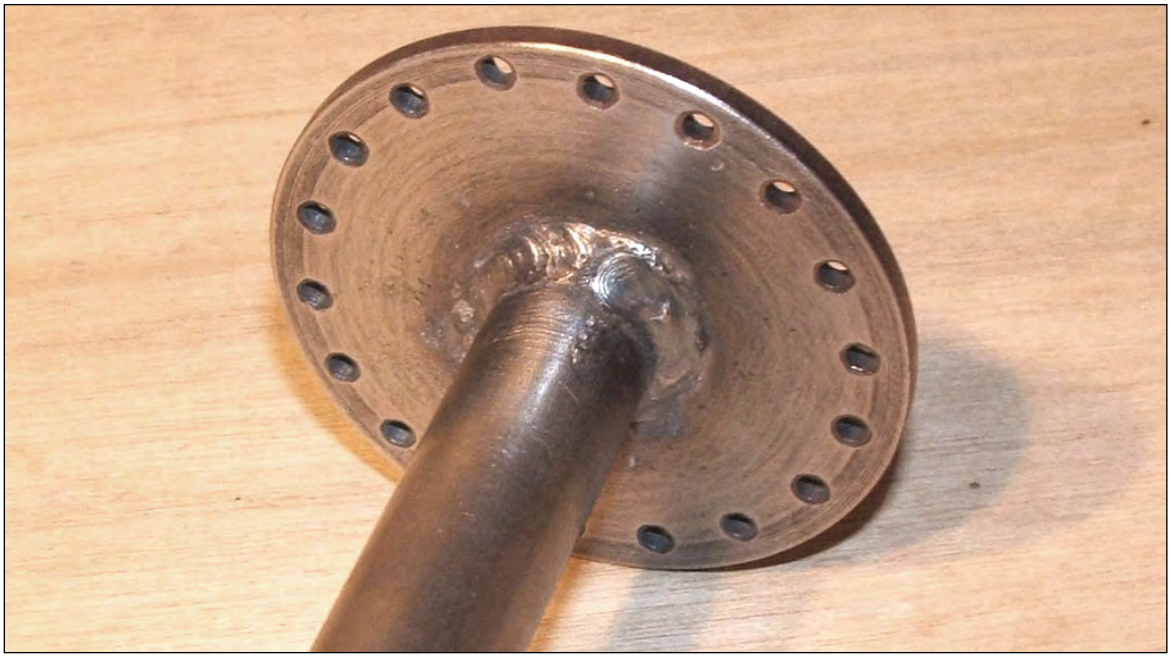

Figure 34 – Welding the inside flange joint

The inner side of the flange joint can be welded around the entire axle as shown in Figure 34 now that the four solid tack welds are securing the flange to the axle. I do this welding in four passes, switching to the opposite site of the axle just as a precaution against distortion due to heat, a good practice when welding a round joint. Once you are done welding the entire distance, place the axle back into the pillow block bearings and give it a spin to check alignment.

A very slight wobble is not a big deal, but if you think there is too much misalignment, a few whacks of the hammer may still cure this. Any misalignment less than the thickness of the actual disc will be acceptable and will have no effect on the wheel lacing process, nor will it show in the final build, so do not spend too much time and effort trying to get the disc spinning with "military accuracy".

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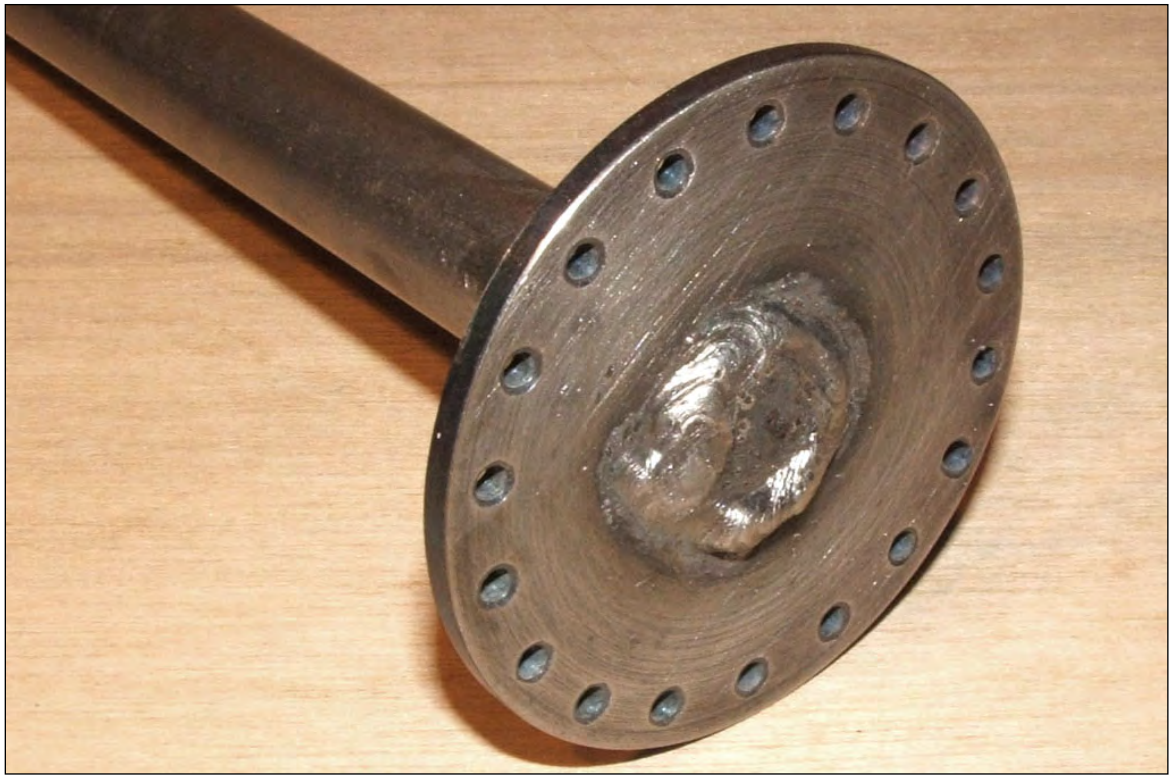

Figure 35 – Completing the flange face welding

Go ahead and weld completely around the front side of the joint now that the rear joint is solid. This can be done with no fear of heat distortion, since the disc cannot move at all now. As shown in Figure 35, a generous amount of weld is placed around the joint to ensure that there will be no pinholes after the face is ground flush in the next few steps.

The final hubs will be very professional looking units once the ends are ground flush, leaving no visible line between the flange face and the axle. If you look at many production trikes, there is a huge, gangly looking bolt sticking out past the hub face in order to secure the hub to the axle, or even worse - a locking pin. These integral hubs avoid that “hacked together” look.

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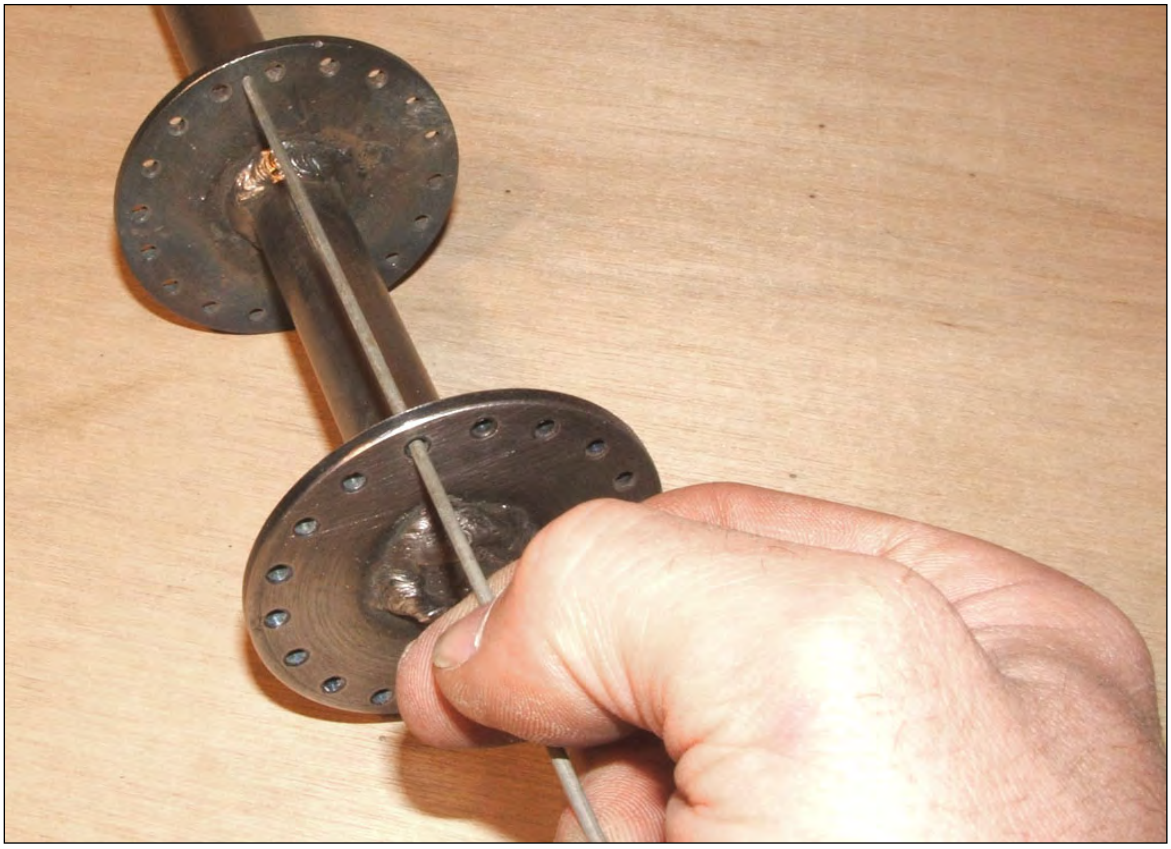

Figure 36 – Opposing spoke holes need to be offset

Before you start on the inner flanges, have a look at the completed hub shown in Figure 36 and you will notice that the holes on each opposing flange are offset to each other. If you place a rod or spoke through one of the holes, it will not enter a hole on the opposing flange; it will hit the space between the holes. Every bicycle hub is manufactured like this, even the cheap steel units, and this is an important thing to do for wheel strength once the spokes are in place. Keep this point in mind when you start tack welding the inner flanges to the axle. A spoke or small welding rod can be used to set up this hole spacing offset between the hub flanges as shown in Figure 36.

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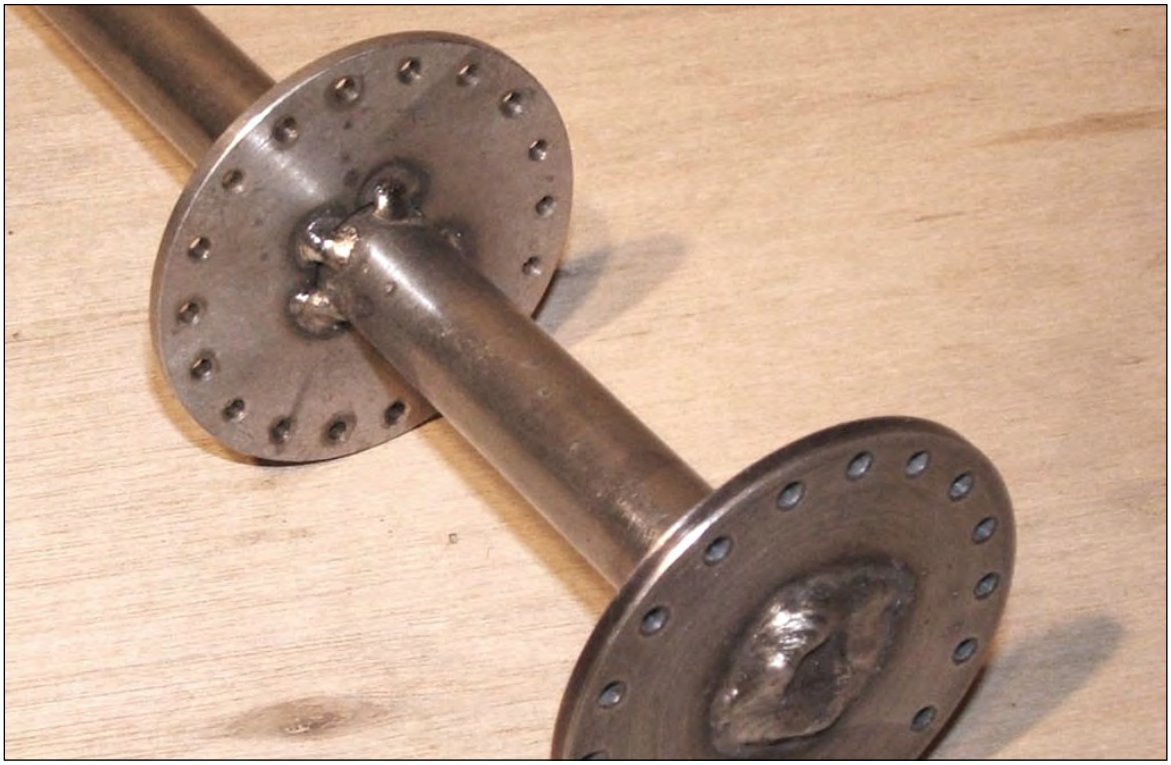

Figure 37 – The inner flange is 3.5 inches from the outer flange

As shown in Figure 37, the same process used to mount the first flange to the axles is also used to mount the inner flanges as well, but do not forget two important points - always place the ground clamp on the axle, not the frame, and make sure that each flange has the holes offset to one another as shown previously in Figure 36. Other than that, tack, hammer, tack, hammer until you have completed all of the welding.

The distance between the flanges will be 3.5 inches as measured from the inside of each face - this makes a much stronger hub than that of a typical bicycle hub and will create very strong wheels that can tolerate the heavier side loaded demanded by a trike. A typical rear bicycle hub has the flanges at 2 inches apart or less, so our 3.5 inch wide hub will be much stronger.

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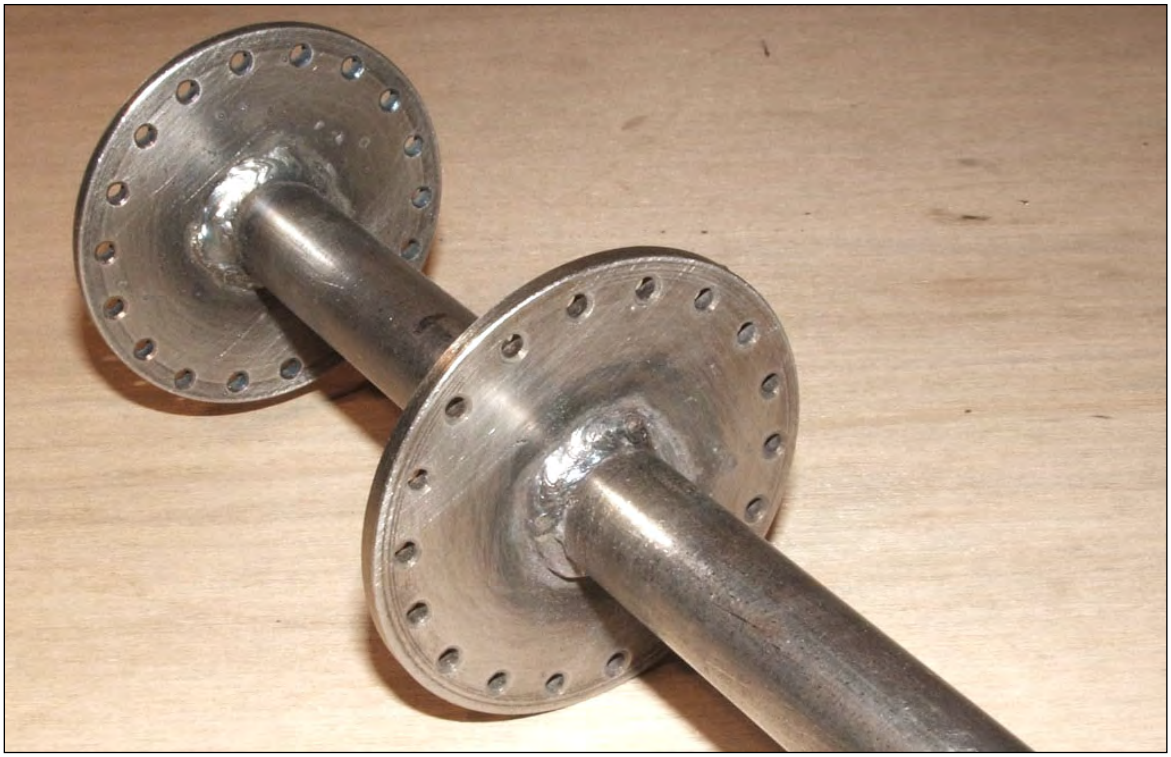

Figure 38 – One axle/hub unit completed

Figure 38 shows one of the completely welded axle/hub units ready to have the face ground flush. These pseudo-hubs will be much stronger than any "hacked to fit" aluminum hub would ever hope to be, and will certainly look much better once they are painted and laced to the rims. When I show off the TimberWolf, I get a lot of comments on the hubs from people who are into bicycle mechanics asking where I purchased those cool trike hubs. I always tell them to take a closer look at the wheels - there are no hubs!

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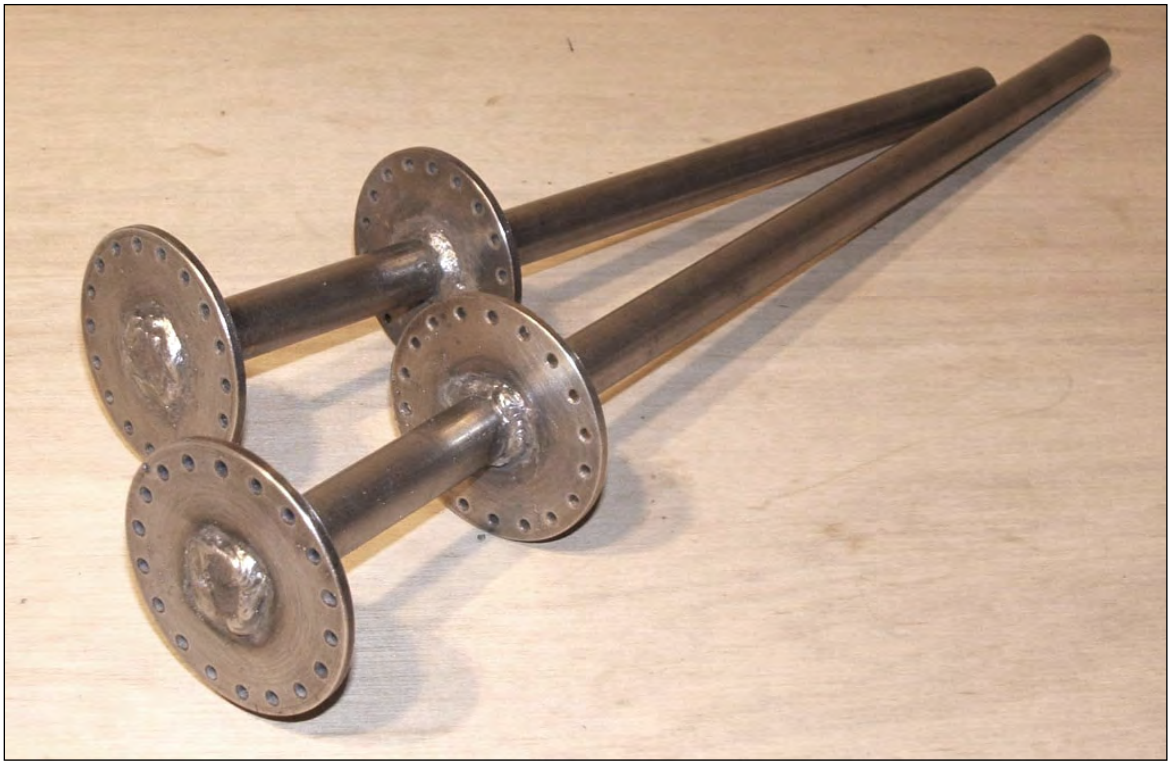

Figure 39 – Axle/hub assemblies completed

Once you have both axle/hub units completed as shown in Figure 39, take your grinder and remove all weld material on the face of each hub until the disk it is perfectly flat. Don't worry about the fact that most of the weld metal will be taken away, the inner flange welds and weld on the other side of this flange will hold the wheel on to the axle. I like to start grinding with a standard grinding disc, then once almost down to the face, place the axle back into the bearings and work it flush with a sanding disc.

You can have a helper turn the axle while you grind, or simply let it spin while you work to create a face that looks as though it were turned down in a lathe. Yes, you could also turn the face down in a lathe of you are lucky enough to have such tools.

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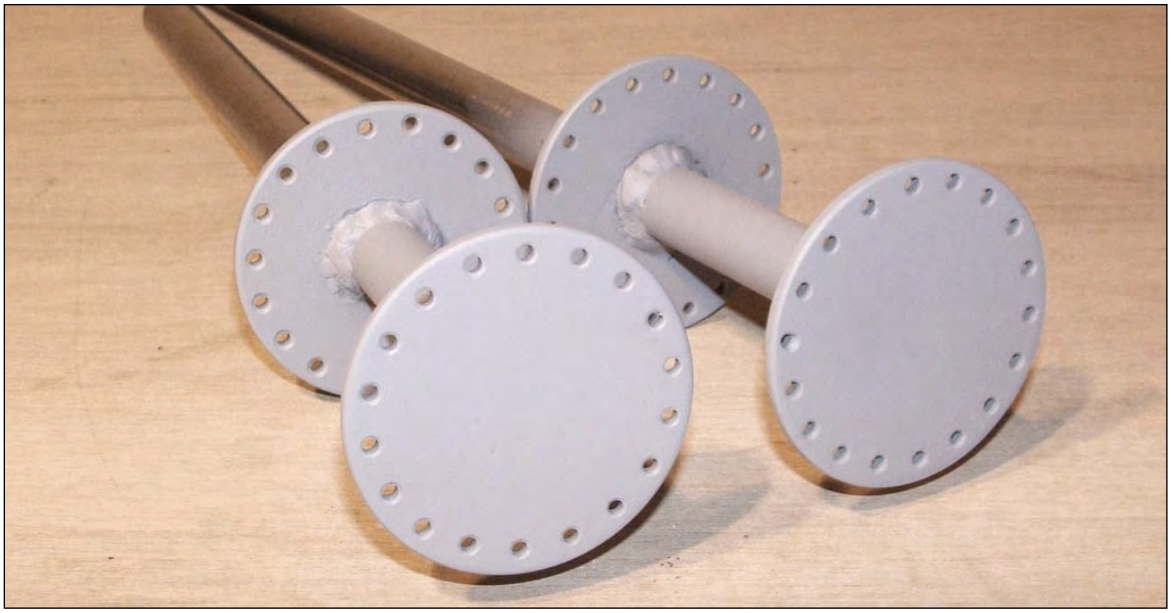

Figure 40 – Flange faces ground and primed

As shown in Figure 40, the hubs are a beautiful bit of work once ground flush and primed for painting. Normally, I save all of the painting for last, but you will need to paint the hubs before you lace the rims, or this task will be very difficult with the spokes installed. Paint only the hub area, not the axle, or it will not slide into the bearings due to the extra thickness of the paint.

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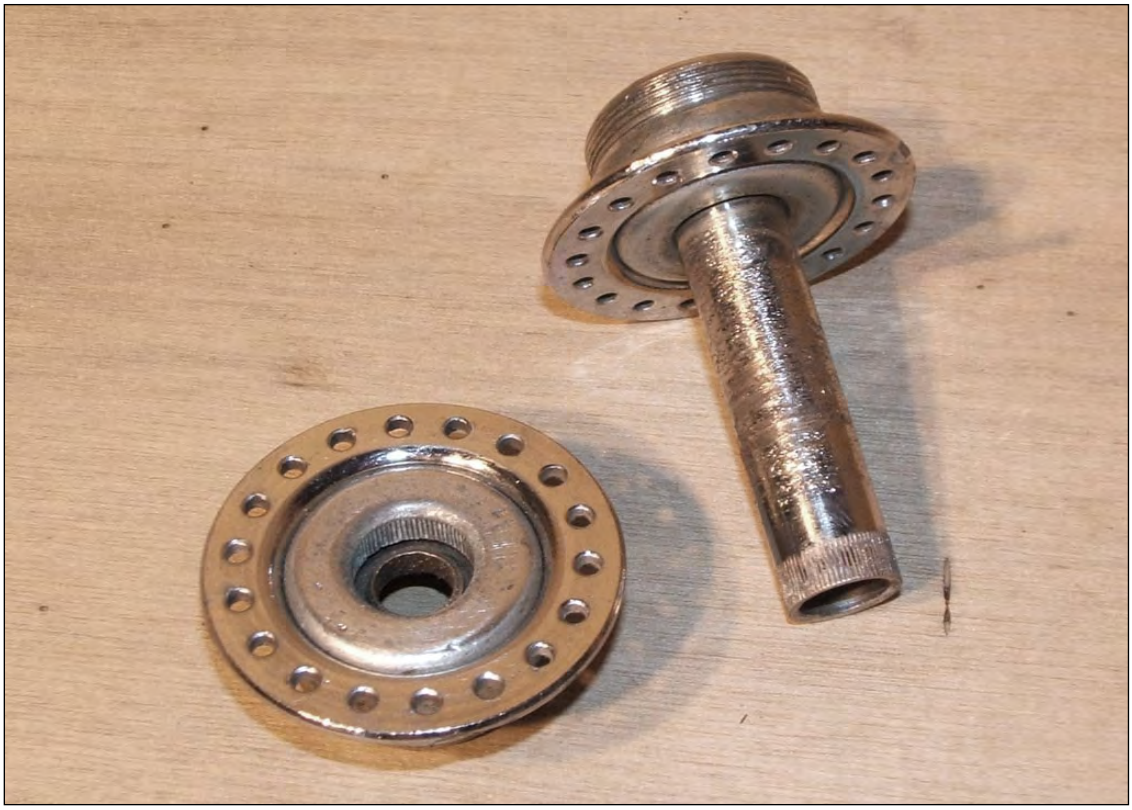

Figure 41 – Cracking apart a steel rear hub

As an alternative to the machined discs or exact sized washers, you could also break apart some cheap steel bicycle hubs to make the flanges, although this method is not as nice looking when completed. Figure 41 shows the cheap steel rear hub separated after a few taps of the hammer while holding the center tube in a vice. There is not much holding the two flanges together because the tension of the tightened spokes in the wheel tends to keep the two flanges pressed tightly to the center tube at all times. Knock the center tube away from both flanges. Do not worry about damaging the center tube in the vice; we will not need it for any part of this project.

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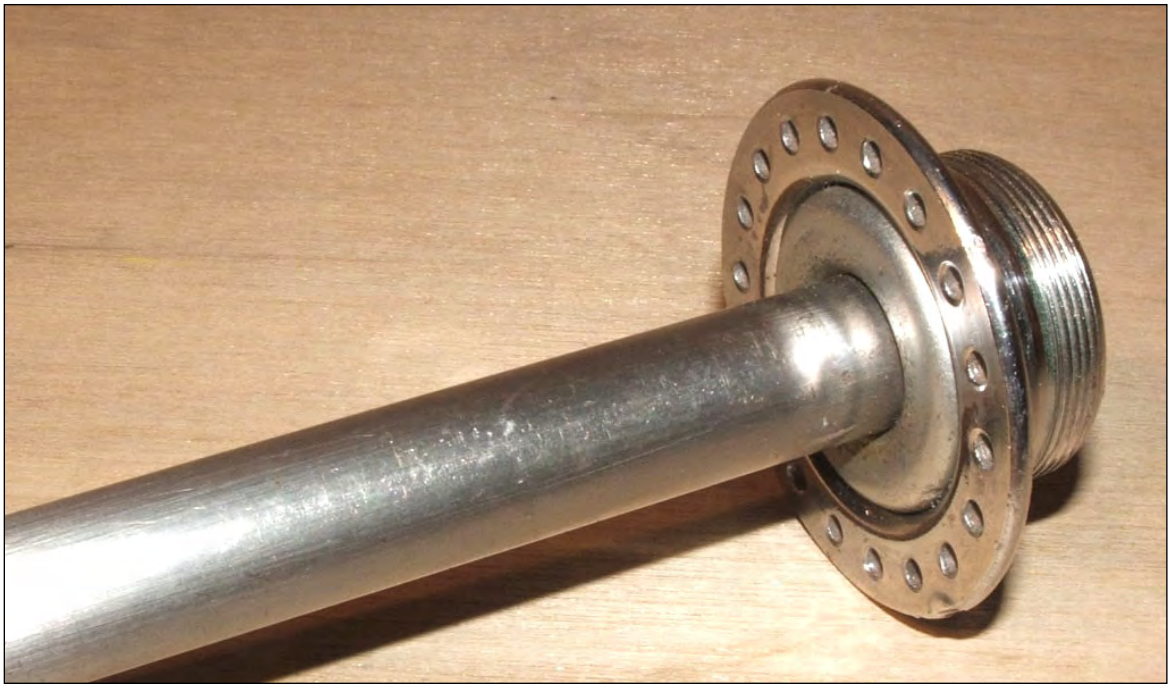

Figure 42 – Test fitting after hand filing the hub hole

If you are lucky, the large hole in the flange will fit snugly onto the 5/8 axles as shown in Figure 42. If the hole is a bit small, a few minutes of hand filing with a round file will take care of that problem as most of the hubs that I took apart will already the correct size or just a tiny bit too small. Some of these hubs nay have very hard material in this area as well, so make sure your round file is new and sharp.

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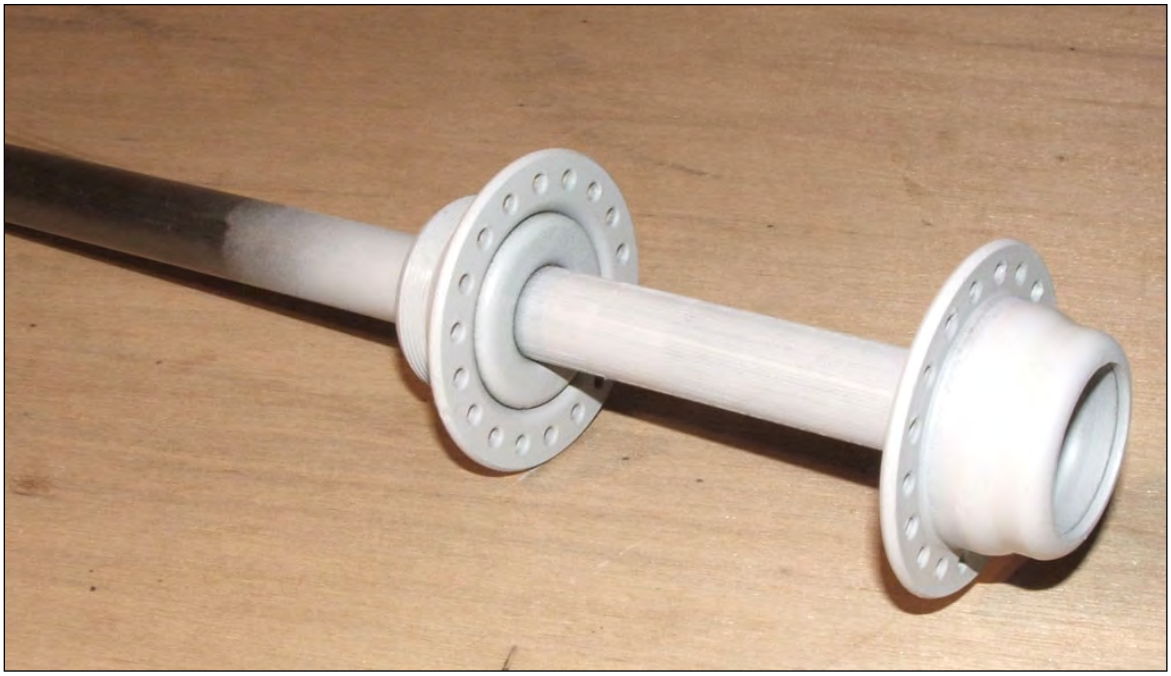

Figure 43 – Alternative hub/axle design completed

Figure 43 shows the alternative no-cost axle/hub completed and ready for lacing. Again, I did not use this system, which is why there is no actual welding done in the photo. To make the flanges secure, the joint at the axle and the outer ring will need to be welded all the way around on the inner sides of the flanges in order to fully secure the parts together. Also, do not forget about the spoke hole offset as explained earlier and shown earlier in Figure 36. The flange faces are placed 3.5 inches apart from each other, just like the machined disc version shown earlier. Basically all of the steps are the same except you are using bicycle hub flanges rather than the steel discs.

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LACING AND TRUING WHEELS

Figure 44 – Lacing wheels is relatively easy

Once you have completed and painted both hub/axle units, it will be time to turn them into delta trike wheels by lacing them into a pair of good 26 inch rims. If you have never thought about building a bicycle wheel from scratch before then let me assure you - anyone can do it! The first thing to do is find a bicycle shop willing to talk to you about your project and advice on a decent double wall rim set as well as the length of spokes you will need to build up your wheels around the custom hubs. Bring one of your hubs into the bicycle shop and tell them you want a decent quality 26 inch rim and the needed spokes to make up a pair of wheels around the hubs. They can calculate the necessary spoke length from a chart and order you the 72 stainless steel spokes for building your wheels.

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You can also ask the bicycle shop to build the wheels for you, but remember that this is certainly a “non standard” job and you will need to supply them with some kind of wheel truing stand as shown in the next photo. You could just ask them how much they would charge you to install the spokes so that you can do the final wheel truing yourself, that way most of the complicated work is done and they would not require a truing stand. I say just go for it and in the unlikely event that you can’t lace a true wheel, pay a bicycle tech to help you at that point.

Installing the spokes is a very easy task that requires no more than placing the spoke in the correct hole and giving the spoke nipple a few turns. It is the actual wheel truing operation that requires some skill or a bit of patience from those new to the art. When you are sourcing your spokes from the bicycle shop, ask them what method of lacing they are using for their length calculations and then do a little Internet searching for that method of wheel lacing. For instance, they may calculate the necessary spoke lengths based on a typical “36 spoke cross 3 wheel”, so type that into Google and enjoy the many well documented wheel building guides that will help you insert the spokes into the correct order. If this is your very first wheel building experience, expect the reading to take you a few hours and the actual loose insertion of spokes to take a few hours per wheel. Also expect to make a few mistakes unless you are one of these “correct first try” magicians.

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Figure 45 – Truing the wheels

Truing the wheels takes a bit of patience, but again, it is not rocket science and can be done by anyone with one working eye, a bit of patience and a flathead screwdriver. A “truing stand” is a jig that holds your wheel and lets you spin it freely, using a fixed point to reference both the side to side and up and down movement of the rim. Of course, with these integrated hub/axle units, a standard truing stand can’t be used so you can just affix the pillow block bearings to a piece of plywood and use a spoke as a fixed reference point as shown in Figure 45. If this is your first time truing a wheel, take your time, turn all spoke heads the same small amount, and keep spinning the rim to check alignment. If you are not sure how much tension should be on the spokes, check an assembled bicycle wheel for reference. If you are planning to let the cycle shop build your wheels, then they will need the truing stand as well.

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Figure 46 – Completed wheels with tires installed

Once you have a set of completed wheels as shown in Figure 46, you will need a tires installed and inflated. The rest of the trike frame will be built from the rear section, so it is important to have the tires installed and inflated from this point on. Tires with aggressive tread should be avoided as they do very little for road traction. Look for a somewhat smooth tread tire that can be inflated to at least 75 PSI. Smoother, harder tires are much faster than soft knobby tires due to having much less rolling resistance. The tires shown in Figure 46 are almost balloon like in profile, but in my area potholes look like moon craters, so that extra rubber helps to protect the rim from a ding.

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FREEHUB ADAPTER

Figure 47 – The freehub adapter

The one part you will need to have machined is the freehub adapter which allows the installation of a screw on multi-speed freehub onto the drive side axle. This part shown in Figure 47 is fairly easy to make, so a friend with a lathe can do it for you, or you could visit your local machine shop to have the work done. Bring a printout of Figure 47 and Drawing 2 so that the machinist knows exactly what you want. It's also a good idea to bring a freehub so they can test the threads.

If you want to avoid the machine shop and keep things low budget, you could actually weld half a rear hub directly to the axle in order to mount the freehub. Look back at Figure 42, and you will see that the dismembered steel hub not only makes the two hub/axle assemblies, but the threaded side can be used as a freehub adapter. You

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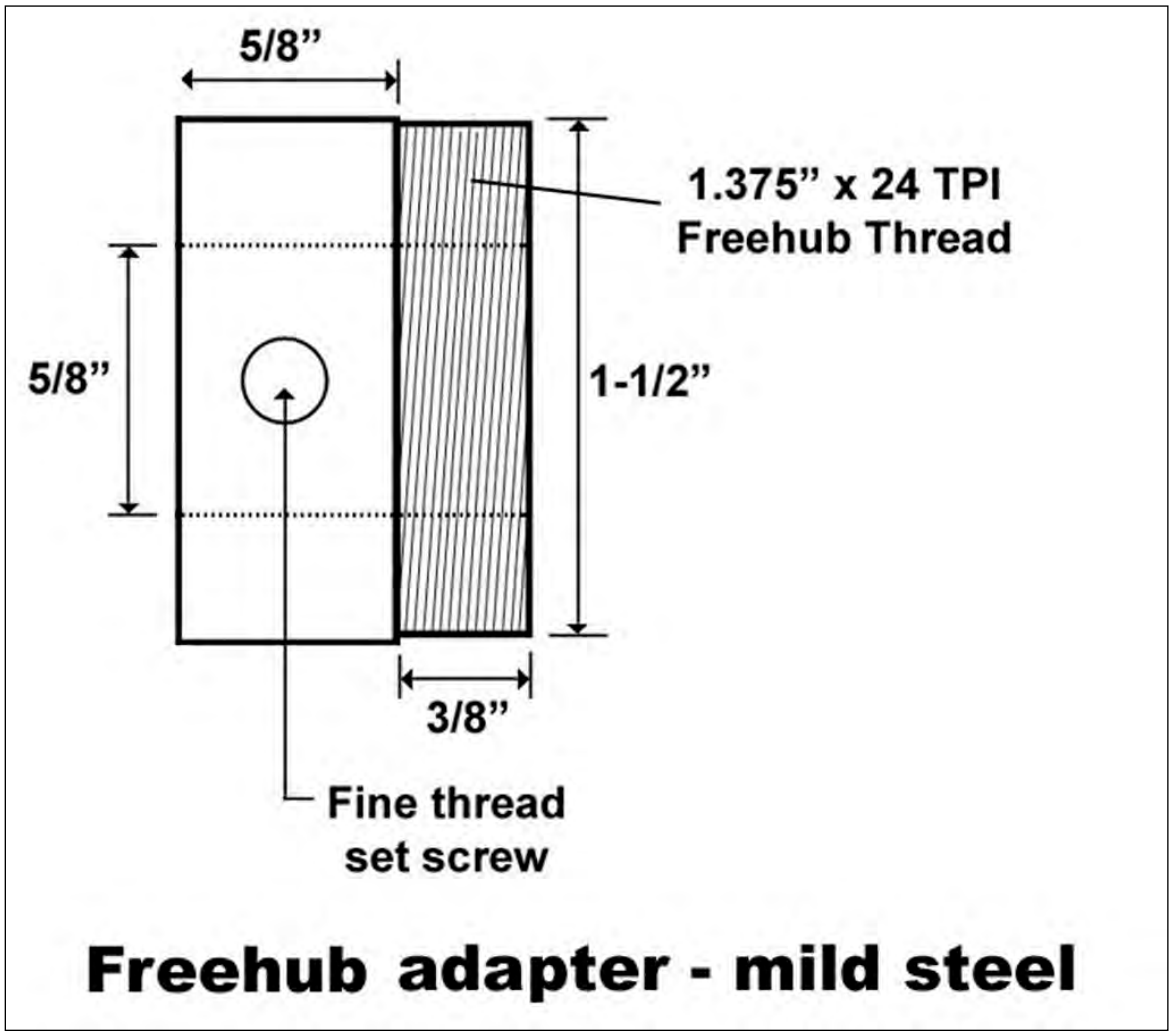
may also find such a part ready made by searching for “Sun trike freehub adapter”, but make sure that the inside hole diameter is 5/8 inches to match your axles.



Drawing 2 – The freehub adapter

The freehub plan shown in Drawing 2 should be printed out and brought to the machine shop along with the thread-on freehub you plan to use. If you plan to build a few trikes or experiment with your own designs, have a few parts made at the same time as the cost does not increase much after the first part is set up on a lathe.

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Figure 48 – A Shimano style threaded freehub

There are two common types of multispeed freehubs – a cassette style unit that allows removal of only the chain ring portion of the freehub from the hub and a thread-on type that can be completely removed from the hub body. The threaded freehub is easily identified by the spline inside the front as shown in Figure 48. This spline is there to allow a special tool to grip the freehub body for removal. I don't like buying special tools, so I will show you how to make your own freehub remover for free that will outlast a store bought tool.

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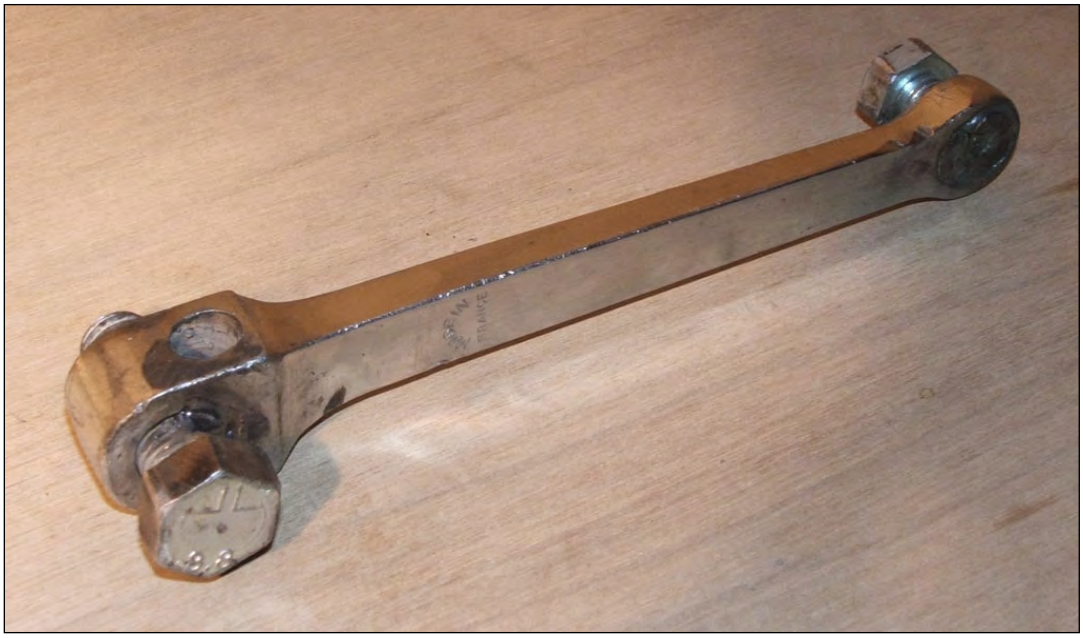

Figure 49 – A simple cheap freehub removal tool

Find a bolt that will fit snugly into the freehub spline, or grind one down that was originally slightly too large until it can be tapped into the spline with minimal force creating a tight lock. This bolt is then welded to an old steel crank arm or similar steel rod to create the indestructible freehub remover that will take any amount of hammer pounding you need to apply in order to remove the old freehub from the threaded hub. Believe me when I say it may take extreme force to unscrew that freehub - usually pound on this tool with a large hammer while holding the rim on the ground.

Oh, and you should always remove the freehub with the rim attached or you will have no chance of holding it - a vice will not hold the hub, trust me. The tool shown in Figure 49 is many years old and has removed more old freehubs than I care to count. For the record, I broke two store bought freehub removers in one month before building this tool. DIY is king!

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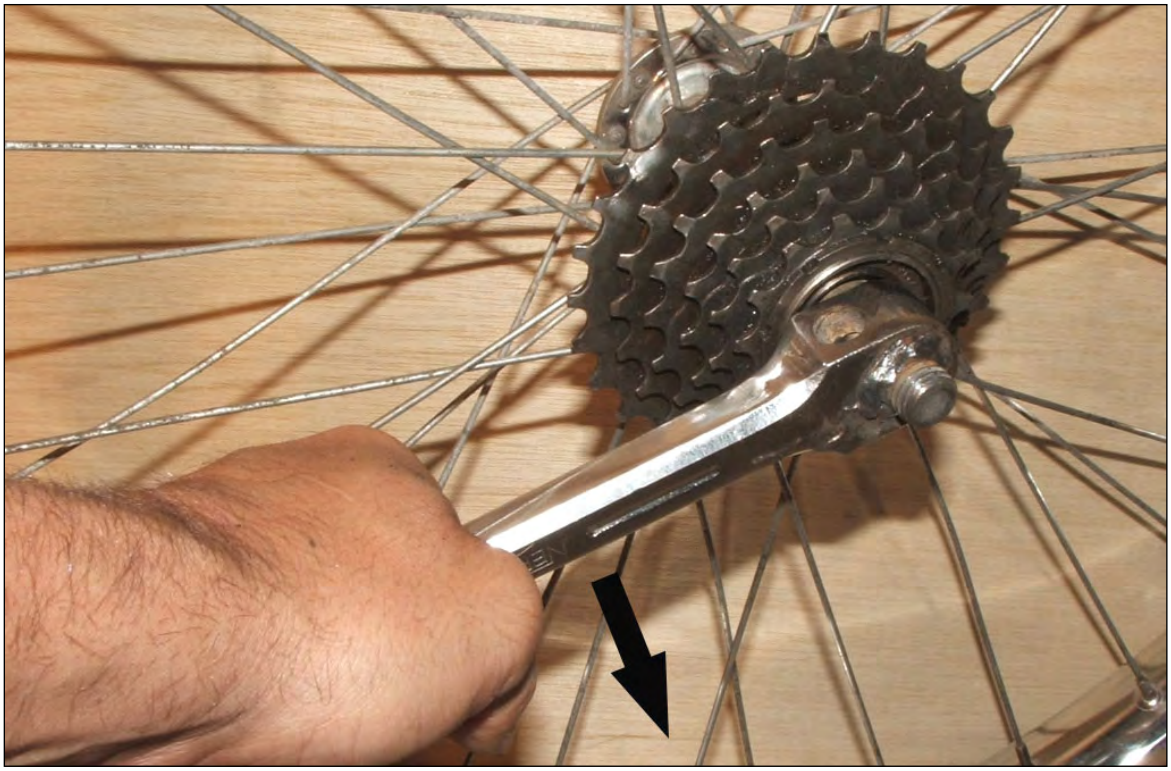

Figure 50 – Unscrew a freehub using counterclockwise torque

Bang the bolt into the spline on the freehub then grab the rim between your legs or stand on a part of the rim to hold it from spinning under the force. You will probably not be able to crank out the freehub by hand unless it is brand new and has not seen much pedaling force. Older wheels will have their freehubs cranked on tightly from years of torque and possibly some rusting as well. Counter clockwise is the direction of removal as shown in Figure 50, just like any bolt, so ensure that you are hitting the correct side of the tool. With a little patience, the freehub will start to unscrew, and the tool always wins. A very long pipe over the handle is also good for increasing your leverage if you can find a way to secure the wheel in place.

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Figure 51 – Removal of the threaded freehub

Here is what the inside of the freehub looks like once it unscrews from the hub (Figure 51). Now, you can remove the hub by unscrewing all of the spokes for later use, or by simply running your cut-off disc around the rim until they are all cut free. Only stainless steel spokes should be re-used for rim building, so if there are any signs of rust on the spokes, trash them, as they are much too cheap to be of any use.

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Figure 52 – The freehub adapter at work

As shown in Figure 52 the machined part will thread right into the free hub with little effort and then slide onto the drive axle for a nice tight fit. Don't crank the free hub into the part just yet, or you may have a tough time removing it, just thread it on until it stops using little force.

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INSTALLING DISC BRAKES

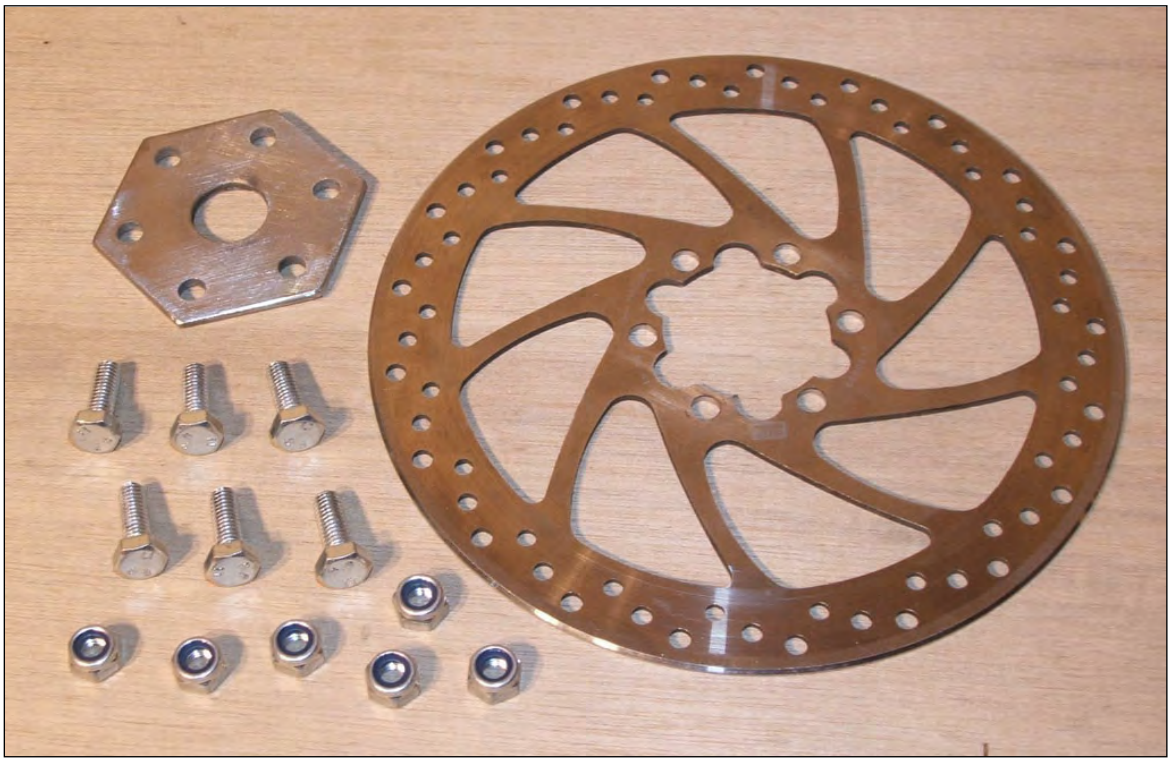

Figure 53 – Disc brake and mounting flange

There are a few various sizes and styles of disc brakes, but all of them can easily be adapted to the axle using a flange made from some flat bar, sheet metal, or even a washer. It really doesn't matter how you create the disc mounting flange as long as it ends up "true" on the axle and has the appropriate holes drilled to allow mounting of whatever disc brake you plan to install. A machined disc similar to the hub flanges could also be used. Mounting this part to the axle will be done using the same methods as shown when welding the hub flanges to the axle.

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Figure 54 – Welding the flange to the axle

The best way to secure the disc brake mounting flange to the right side axle is by welding it directly to the axle. Braking forces are many times higher than pedaling forces, so the flange needs to be very strong. The placement of the flange will put the disc rotor centered between the two bearing support tubes as shown in the next photo (Figure 55). Also, one of the bearings needs to be installed (closest to the wheel) on the axle before you weld, since you will not be able to do so later. Don't worry about the bearing being permanently fixed – it will never wear out doing its duty on this trike. Also, the disc rotor is installed on the side of the flange furthest from the wheel so that it can be removed if worn.

Figure 54 shows the disc brake mounting flange welded directly to the axle using the "tack, tap, and weld" system used to weld the hub flanges. Also shown is one of the bearings installed close to the wheel.

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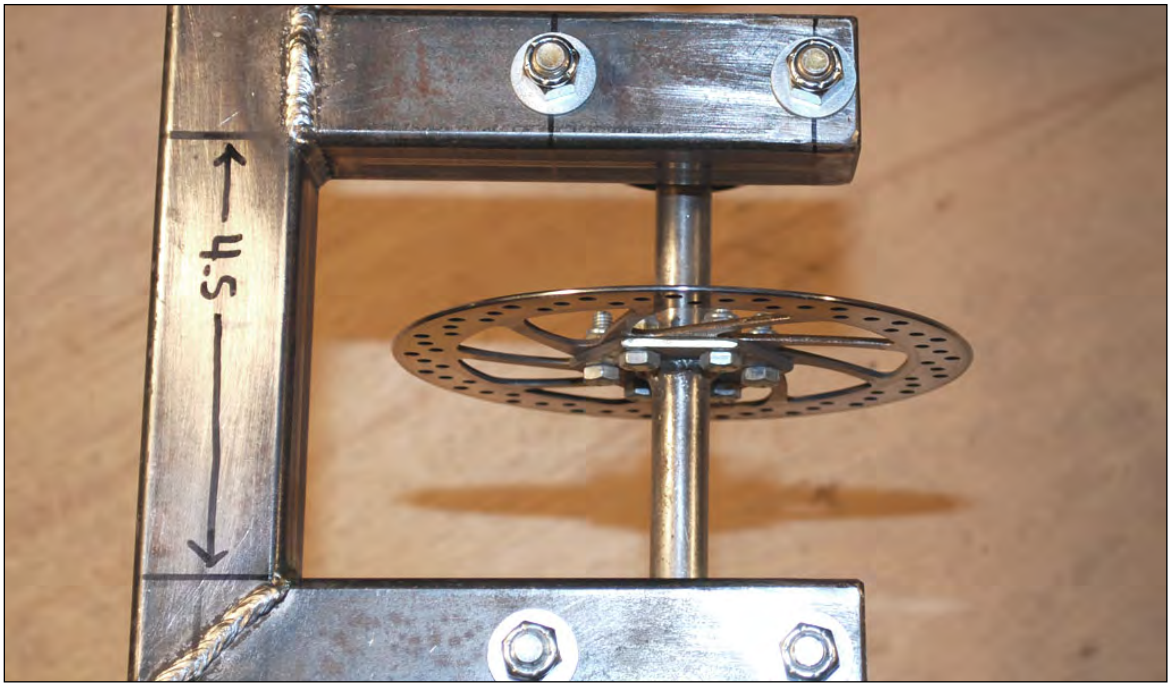

Figure 55 – Disc brake rotor position

The disc brake rotor should be placed centered between the two tubes so you have more room to design whatever disc brake mounting hardware that will be needed. Figure 55 shows the disc brake rotor installed on the mounting flange so that it is bolted onto the flange side furthest from the wheel to allow later removal. Also, take note of the direction of rotation of the disc rotor, which is shown on the rotor with a stamped arrow. The indicated direction of rotation should be the same as the rotation of your wheel as if moving forward.

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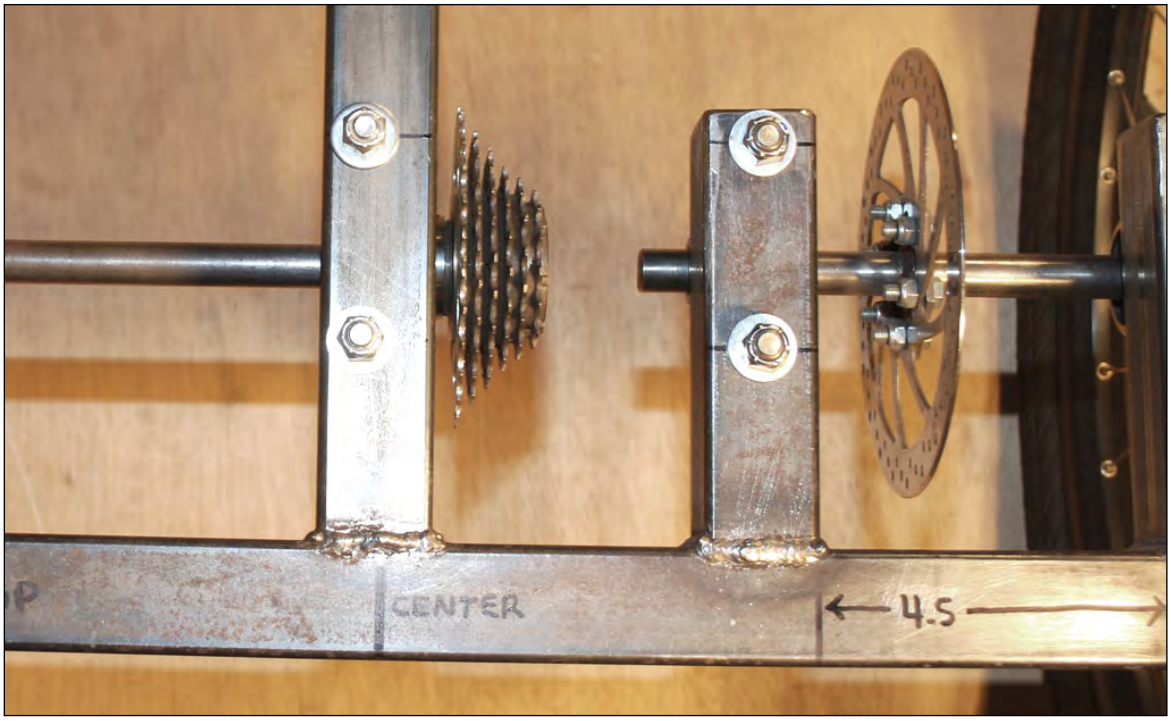

Figure 56 – Test fitting the freehub

Figure 56 shows how the freehub will be installed so that there is about half an inch between the square tubing and the largest chain ring. This clearance is necessary since the chain will have a certain thickness and cannot be allowed to rub on the frame. You can test this gap by placing a chain on the largest chain ring to ensure that it will have adequate clearance between the frame tubing.

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WELDING THE FREEHUB ADAPTER

Figure 57 – Welding the freehub adapter to the axle

The freehub adapter can be affixed to the axle using several methods. The easiest and most reliable method is to simply weld it in place around the face as shown in Figure 57. This method is bullet proof, in my opinion, and does not prevent the removal of the freehub although it does lock both bearings onto the axle permanently. Again, the bearings are designed for much harder duties and will probably outlast you, so having the permanently affixed to the axle is not much of a concern.

The other method of mounting the freehub adapter to the axle is via setscrew or bolt through the axle. A ¼ inch hard set screw fed into a small hole drilled half way through the axle will probably be enough for most riders, but if you are like me and enjoy a good sprint or drag race against traffic at a red light, then you should weld the part in

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place. A set screw can take a decent amount of force, but will not stand up to a very strong rider who prefers to start from a dead stop in high gear.

Figure 58 – Trimming the axles

With the freehub adapter installed on the axle, you can now screw on the freehub as shown in Figure 58. At this point, don't tighten up the freehub too much as you still may want to remove it a few times before final assembly. If you find that the freehub becomes stuck on the adapter, you can always rely on your trusty freehub removal tool to set if free once again.

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Figure 59 – Trimming the axles

Once you have mounted your disc brake flange, as well as the freehub adapter to the axles, trim any of the excess axle material that is unnecessary so that you have a completed rear frame assembly as shown in Figure 59. From here, the rest of the frame is based on the height of the main rear boom tube as it sits parallel to the ground. This delta trike rear assembly can actually be used as a basis for many different types of trikes as it only requires a chain to give it power. Our DeltaWolf Racing Trike and DeltaRunner Trike have almost the same rear assembly, so you could take this design in almost any conceivable direction if you wanted to. Ok, now on to the suspension components of the trike.

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REAR SUSPENSION

Figure 60 – Salvaging the suspension parts from an old frame

The TimberWolf Trike has rear suspension that works exactly the same way as the suspension on a typical mountain bike - a pivot and a suspension spring to help take up shock from bumps in the road. In fact, all of the suspension parts can be salvaged from an old or new frame like the one shown in Figure 60. You will need the actual suspension spring, the pivot bearings and mounting hardware as well as the mounting hardware that holds the suspension spring to the frame. There are many different styles of mountain bike suspension frames, but all of them can be used for parts, so don't be too fussy when looking for a frame to cut up. As long as the spring and pivot seem to be in working order, you will be able to make use of the suspension parts.

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Figure 61 – The swingarm pivot tube needs to be cut from the frame

The small round tube shown in Figure 61 is the suspension pivot tube that contains the brass or plastic bushings that allow the rear triangle swingarm to move up and down in response to rough terrain. This tube may look different depending on the style of frame you are using for parts, but generally, the bearing components are all the same - a tube that has a pair of press fit brass or plastic bushings and a main pin to hold the swing arm in place. Remove the swing arm and then tap out the bearings using a rod or screwdriver to leave the pivot tube empty as shown in Figure 61.

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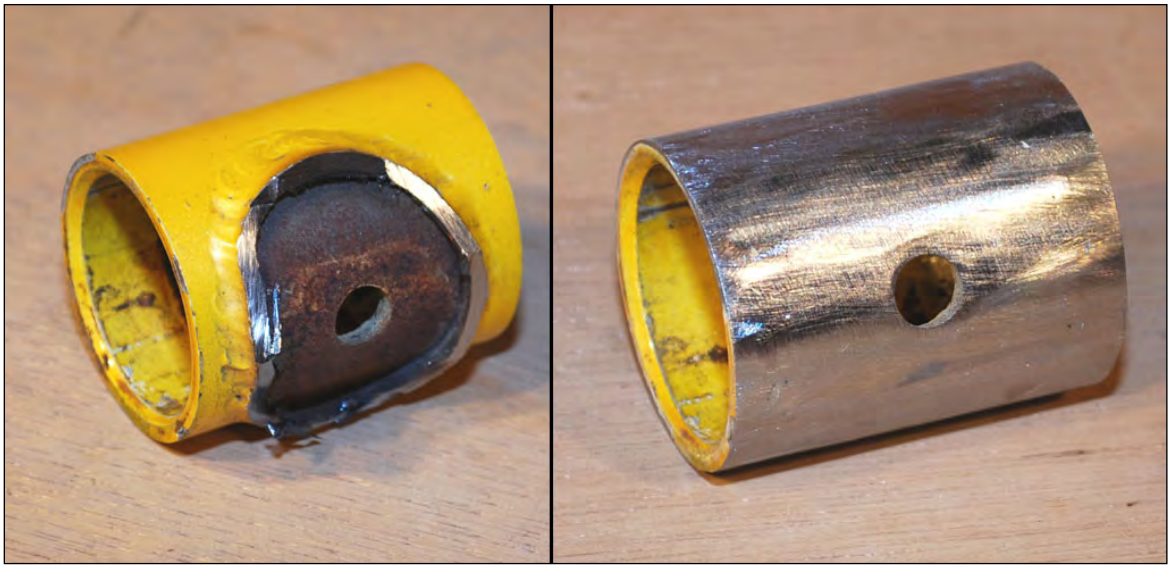

Figure 62 – Removing the pivot tube from the frame

To remove the suspension pivot tube form the frame, first cut along the weld using a zip disc or hacksaw to remove the part as shown in Figure 62 (left side), taking care not to cut into the pivot tube. Do this operation with the bearings removed from the tube as the heat from the grinder cutting could melt the plastic bearings. The right side of Figure 62 shows the suspension pivot tube after a little fork with the sanding disc, which cleans up any of the excess tubing and paint from the area.

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Figure 63 – The bare suspension pivot tube along with the bearing hardware

The suspension pivot tube is shown in Figure 63 along with all of the bearing hardware, suspension spring, and the mounting tabs still attached to the rear triangle. Since you now have the main suspension pivot tube removed from the frame, you need to remove the other part of the hardware that attached the rear triangle to the bearing hardware. In my frame shown in Figure 63, the rear triangle hardware is just a pair of mounting tabs that hold the main pin through the bearings. Your hardware may differ, but either way, you can still remove it from the frame. Also, ensure that the rear triangle hardware is steel, not aluminum or you will not be able to weld it to your new frame.

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MOUNTING TABS

Figure 64 – Removing the rear triangle suspension support hardware

If your rear triangle has a pair of mounting tabs like the ones shown in Figure 64, then cut them away from the other frame tubing, including as much material on the tabs as possible. Don't worry about the bottom bracket if it looks like the one shown in Figure 64 because it will not be used for this project. Read ahead to see how the suspension on the TimberWolf works if your hardware is significantly different than what is shown here.

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Figure 65 – Grinding the two parts so they are identical in size

Once you have cut the rear triangle support hardware from the frame, place the two parts in a vice using the center hole as a guide to align them as shown in Figure 65. Grind the area that was cut so that both parts end up exactly the same size.

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PIVOT TUBE

Figure 66 – The suspension pivot parts can now be used on your project

Your suspension pivot hardware may not look exactly like the components shown in Figure 66, but they will still be easy to adapt to the square tube from the TimberWolf. You could even create your own pivot hardware using a pair of half inch brass bushings, a bolt and some round tubing to press fit the bushings, but if you can salvage the hardware from a bicycle frame, it will be less work.

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Figure 67 – Marking the end of the rear boom tube for the fish-mouth cut

The suspension pivot tube will mount directly to the open end of the main rear boom tube, so a fish-mouth cut must be made so the parts can be welded together. Figure 114 ahead shows a close view of how the pivot tube will be installed so that the rear portion of the trike can move up and down in response to the bumps in the road. The resulting suspension system is basically the same on the TimberWolf as it is on any suspension bicycle.

Place the suspension pivot tube on each side of the boom tube so you can trace a line that will meet from corner to corner in an arc as shown in Figure 67. Remember, these cuts are made on the sides of the frame tubing, not the top and bottom. Looking ahead at Figure 114 shows this in more detail.

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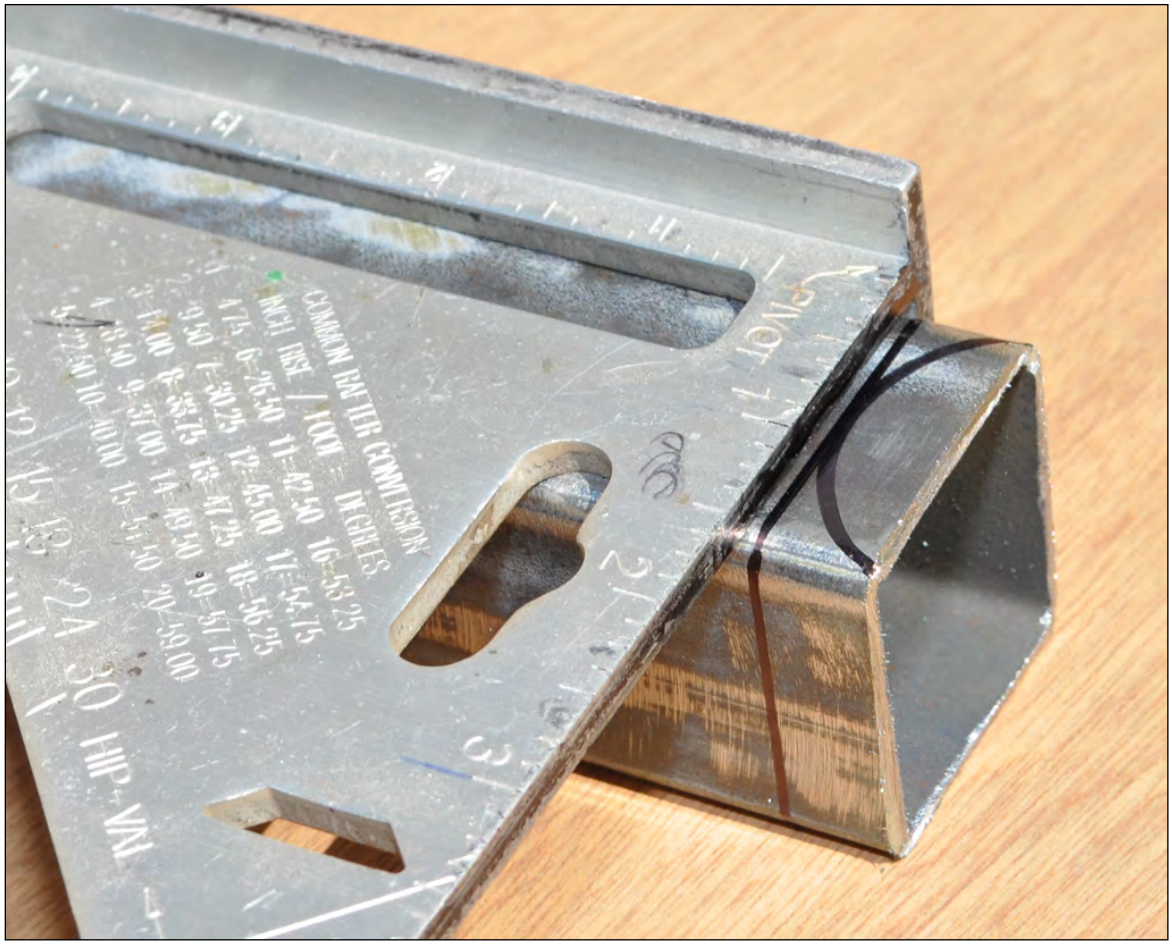

Figure 68 – Transfer the fish-mouth to the other side of the tube

To ensure that the fish-mouth will be the same on each side of the rear boom tube, use a square to transfer a line around the tubing as shown in Figure 68 so you can mark the depth equally on each side of the tube. This should be done anytime an equal cut has to be made on opposing sides of a square tube.

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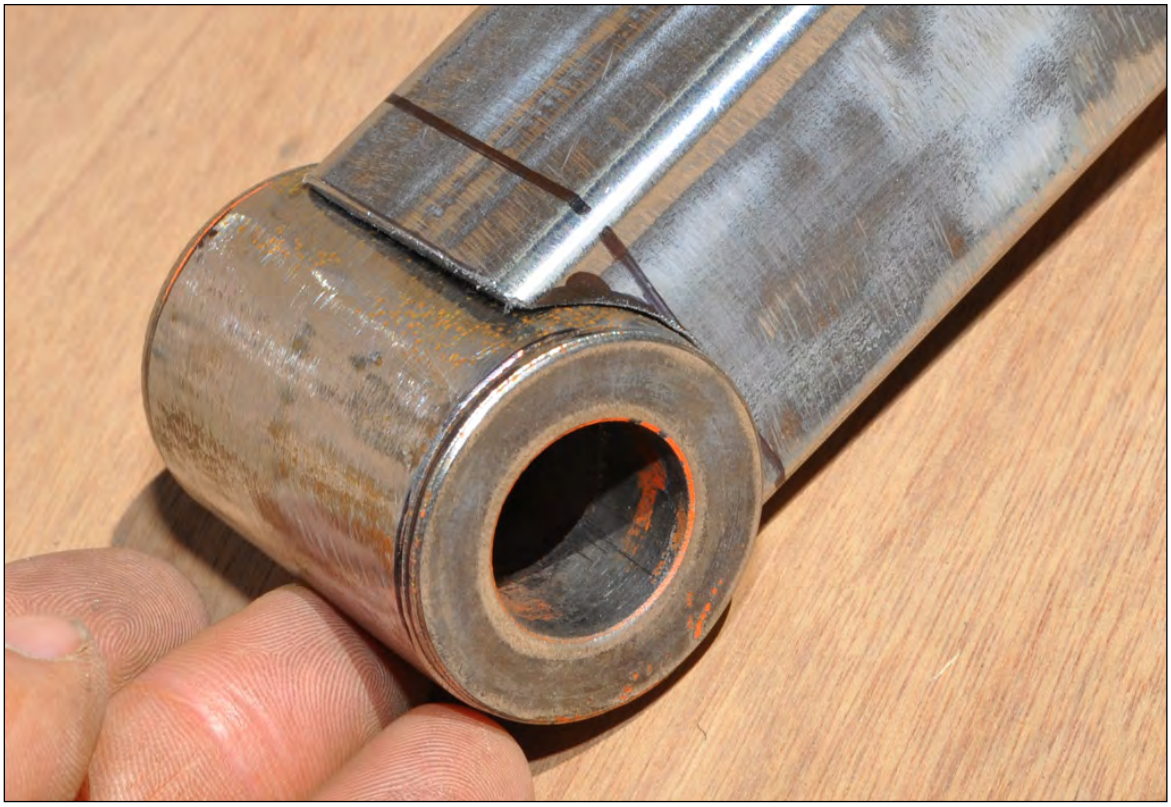

Figure 69 – Test fitting the suspension tube into the fish-mouth cutout

The suspension pivot tube should fit neatly into the fish-mouth cut made in the end of the main rear boom tube as shown in Figure 69. It is important that the pivot tube be installed at 90 degrees to the square tube so that the two part of the frame connected by the pivot will be in line with each other.

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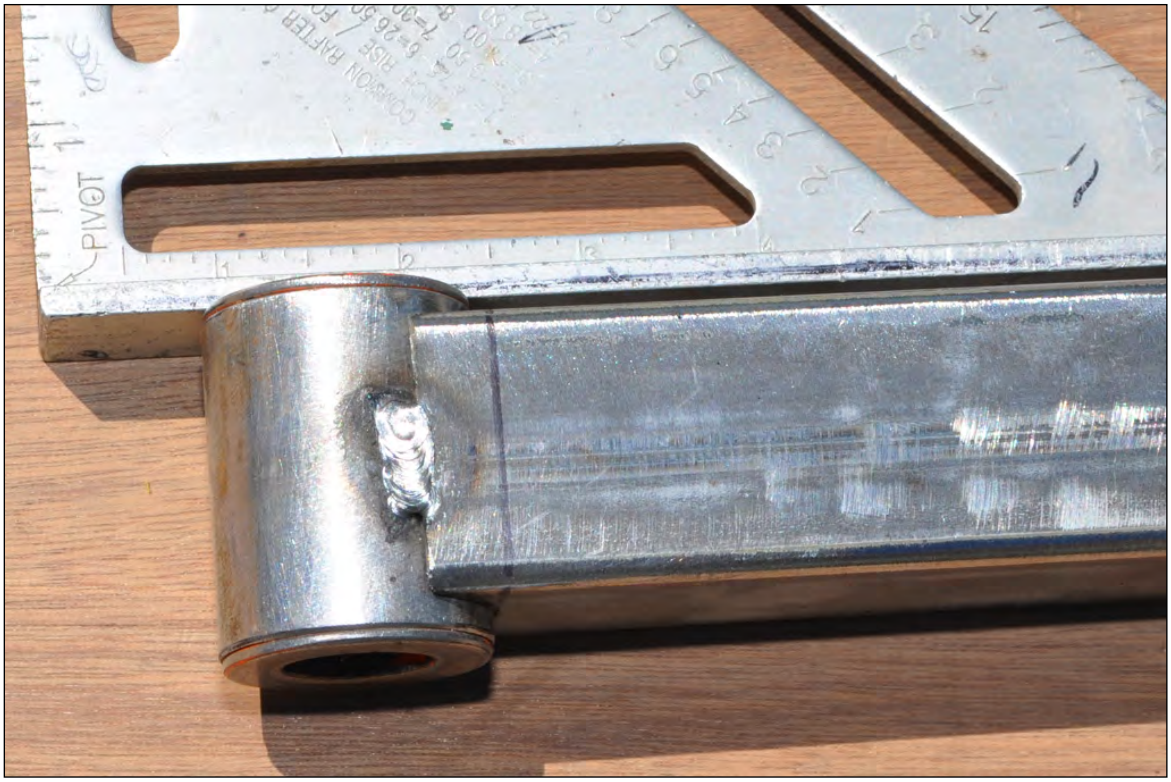

Figure 70 – Checking the alignment with the frame tubing

Place a single tack weld on the joint as shown in Figure 70 and then verify that the suspension pivot tube is at 90 degrees to the frame tube by placing a flat edge on the suspension tube as shown in Figure 70. The flat straight edge should line up parallel to the frame tubing if you place it flat on either end of the suspension pivot tube. Tap the part with a hammer to make any necessary corrections before making any more welds on the joint. Also, ensure that you remove any plastic bearing parts from the suspension tube while welding. My bearings are made of brass, so it was ok to have them installed during the welding process.

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Figure 71 – Welding the top of the pivot tube joint

Like all of the other welding to be done, order of operations is important to minimize distortion from welding heat. With the suspension pivot tube aligned and tack welded on one side, run the first bead of weld across the top of the joint as shown in Figure 71. Weld the opposite side next, which will help minimize any side-to-side distortions that may occur when the sides of the joint are welded.

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Figure 72 – The sides of the joint are welded last

Once you have the top and bottom of the suspension pivot tube joints welded, continue with the sides of the joint as shown in Figure 72. There will likely not be a lot of space between the bearing and tubing surface, so be careful and run a smaller bead so that you don't burn away the edge of the round tube or melt the metal bearings that may still be installed inside the tube.

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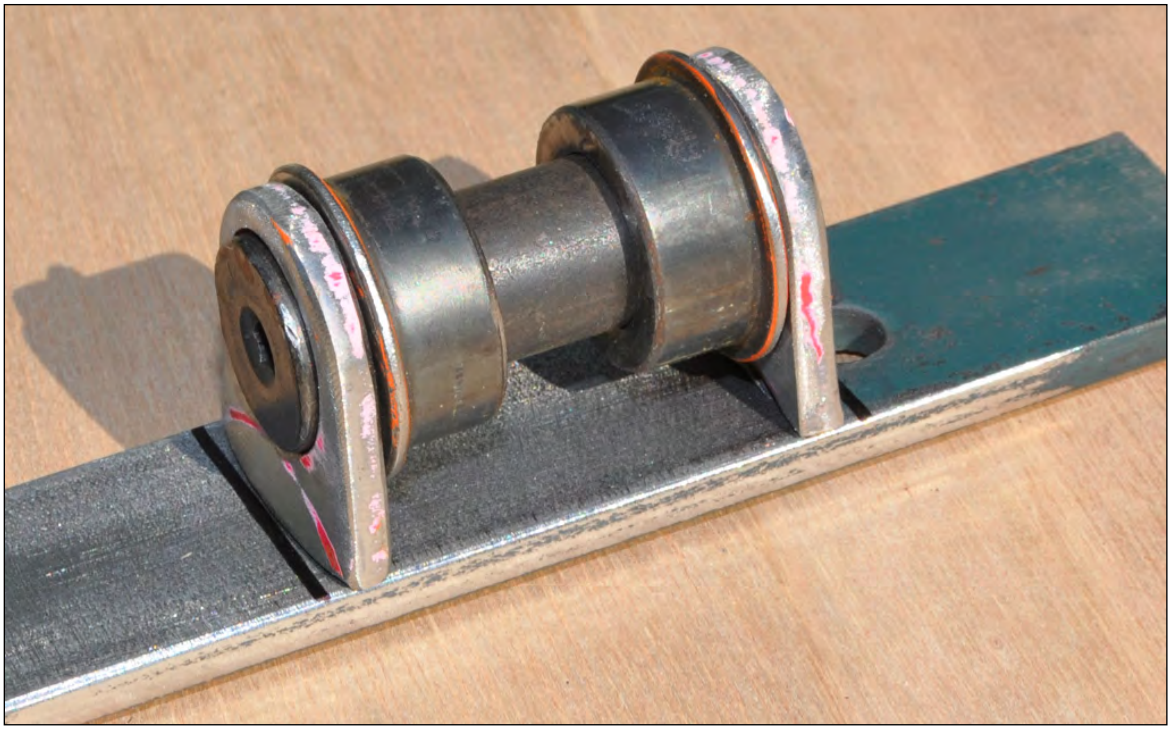

Figure 73 – Cutting a plate to join the suspension tabs

The two small arms that you cut from the rear triangle need to be fastened together in order to affix them to the other part of the TimberWolf frame, so a small length of flatbar with a thickness similar to that of the two arms needs to be cut. Of course, your parts may differ, but in the end the goals are the same, which is a pivot in the frame as shown ahead in Figure 89. The piece of flatbar that I ended up using was 3/16 thick and cut as wide as needed by laying the part over it as shown in Figure 73.

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Figure 74 – There should be a small gap to allow the tube to rotate

When you are creating the other half of the suspension pivot hardware, ensure that the pivot tube has a small space as shown in Figure 74 so that it can move freely and not rub against any of the new parts being made. Think of this assembly as a large door hinge - it will function much the same way.

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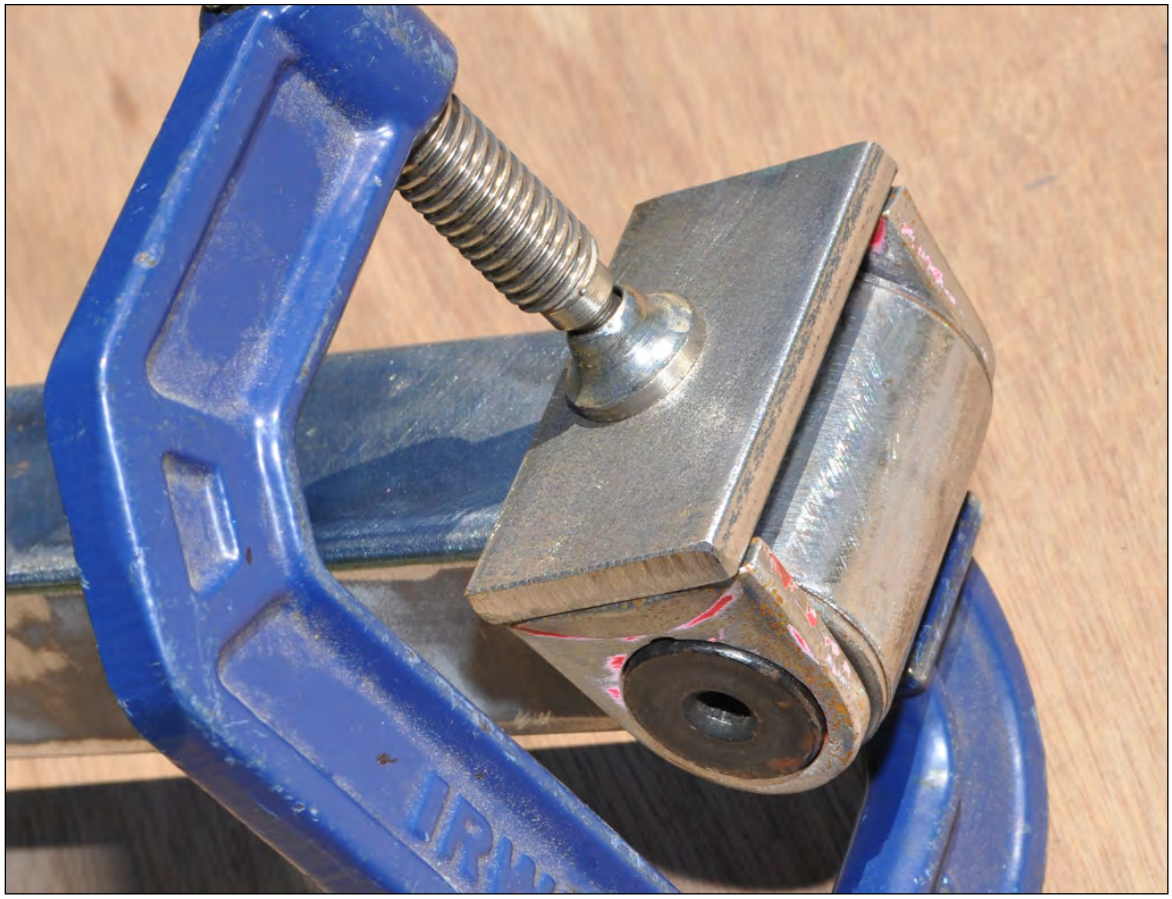

Figure 75 – Setting up the new part for welding

The suspension pivot hardware must allow the two parts of the frame boom to move up and down, but they also must keep both parts perfectly inline so your frame is not skewed to one side. If your hardware is similar to mine and you have made a plate like the one shown in Figure 74, then the clamping method shown in Figure 75 will help keep the parts in good alignment as you weld them together. The frame tubing is being used as a guide here. Remember that you cannot heat plastic bearings, so do not try this if your bearings are not made of metal.

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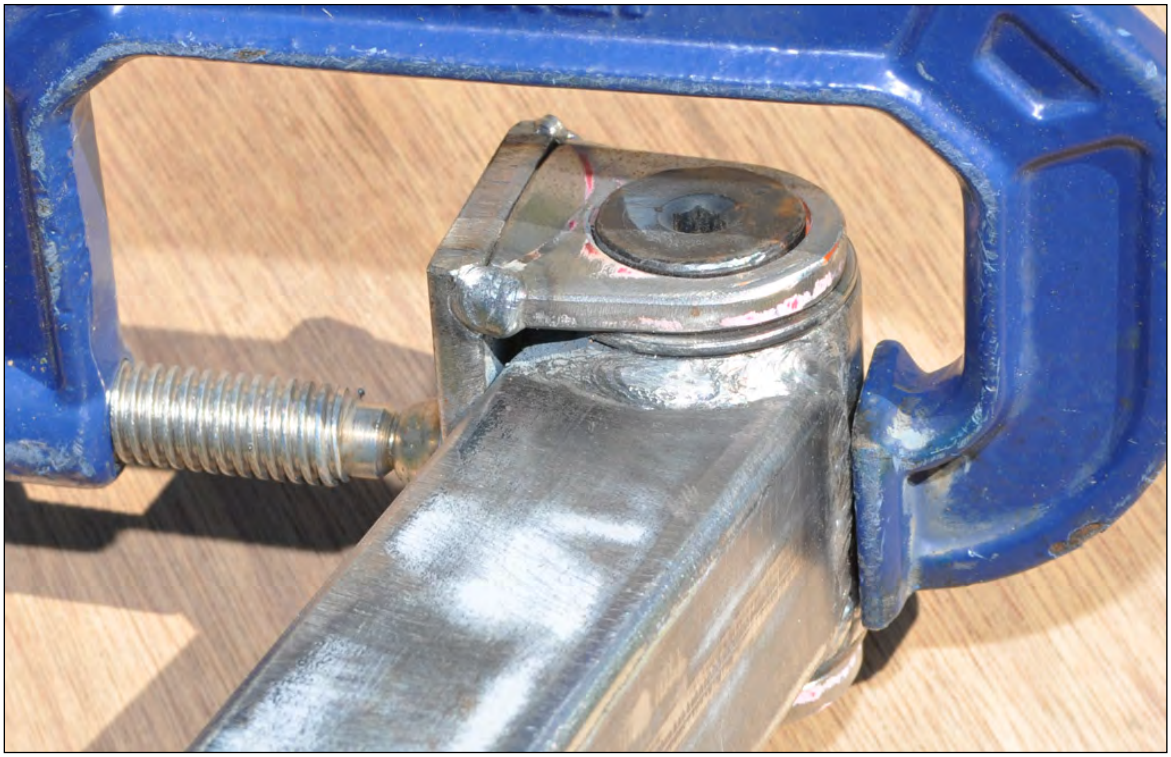

Figure 76 – Tack weld the new plate on all four corners

With the clamp holding the new plate securely and aligned to the frame tubing, apply a solid tack weld at each corner to secure the parts together. Since the new plate is resting directly on the frame tubing, alignment is practically guaranteed.

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Figure 77 – Complete the welding with the clamp still installed

The welding can be completed along the edge of the joint as shown in Figure 77, keeping the clamp installed to hold the parts in place. Only the outer edge of the joint needs to be welded as there may not be enough space between the inside of the joint and the pivot tube to weld the inside. This completes the rear section of the frame and the suspension link so the rest of the frame can now be made.

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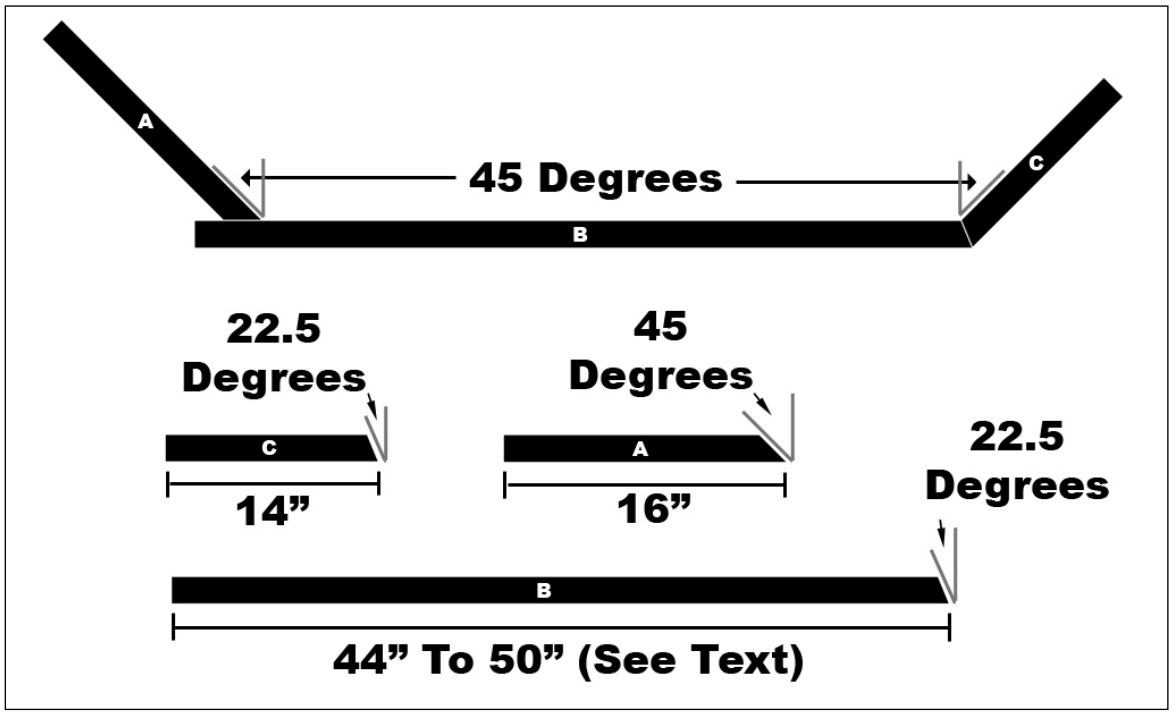
MAIN FRAME



Drawing 3 – Dimensions for the front frame tubes

The TimberWolf main frame is made up of three different 1.5 inch square tubes as shown in Drawing 3. The main boom tube (B) connects all of the other tubes to the frame and it also carries the head tube and rear suspension pivot. This main boom (B) runs parallel to the ground and also joins the rear seat tube (A) and the front boom (C) to form the shape of the frame. To see how the actual frame relates to the tubing shown in Drawing 3, have a look ahead to Figure 85.

The main section of the TimberWolf frame is basically a cradle with tubes placed at 135 degrees at each end. In Drawing 3, the angles of the frame tubes are shown as 45 degrees because they are taken from a 90 degree point off the main boom (B). You can see why this is done by referring to the rear seat tube (A) in Drawing 3, which would be cut by drawing a 45 degree angle from the side of the tube using a 45 degree square to mark a cut line. You can also fold a piece of paper in half to create a 45 degree template

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that can be used to mark the tube for cutting. The angle cuts on tube (B) and tube (C) are both made at 22.5 degrees so when they are placed together, forms the 45 degree angle.

INSEAM MEASUREMENT

Before making any cuts, you must decide how long to make the main frame boom tube (B), which will dictate how far ahead the adjustable bottom bracket can be moved to accommodate the tallest rider. Having the ability to slide the cranks along the main boom allows riders of most heights to set up the trike to their correct inseam, but there is no point having a longer trike than you really need. To calculate the length of the main boom, you will need the inseam measurement of the tallest rider that will be using the trike. To calculate "recumbent inseam", have the tallest rider sit with his or her back against a wall as shown in Drawing 4 and then measure the distance from the wall to the underside of his or her foot while wearing shoes.

Drawing 4 – Measuring leg length or "recumbent inseam"

The measurement from the wall to the underside of the tallest rider's shoe is what I call "recumbent inseam". This length will be used to calculate the length of the main boom tube (tube B) so that it isn't longer than necessary. Actually, the length that you will cut the main boom is the same as the length you acquire from Drawing 4, which takes into account 2 inches of seat thickness and front wheel to crank overlap. My "recumbent inseam" measurement was exactly 44 inches, so I cut the main boom to the same length of 44 inches.

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FRAME TUBING

You will likely set your cranks to one length and leave them there, but if you think you may want to adjust them for a taller rider or possibly sell/lend your trike to someone else, then add a few inches to the boom to be safe; it will not affect your handling characteristics. A few extra inches of boom length will also allow you to try out alternative seat configurations such as a mesh seat, which will push the rider a few inches closer to the front of the trike as compared to a basic wood and foam seat.

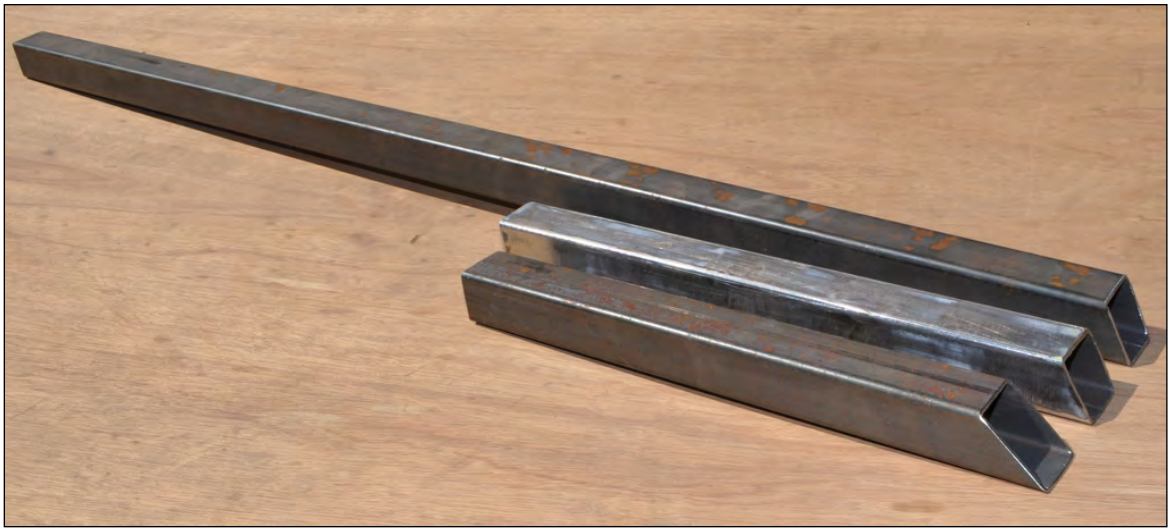

Figure 78 – Cutting the 3 main frame tubes as per Drawing 3

Once you have worked out the length of the main boom tube (B) using your recumbent inseam measurement, cut all 3 tubes based on Drawing 3. You will end up with the three main boom tubes as shown in Figure 78. Both tubes (B) and (C) have a 22.5 degree cut taken from the 90 degree end and tube (A) has a 45 degree cut as taken from the 90 degree end. If you do not have a 45 degree square or an adjustable angle finder, you can make a 45 degree template by folding a piece of paper in half and a 22.5 degree template by folding it over twice. The angle formed between the seat back tube (A) and the main boom tube (B) determines the angle of the seat, which will become 135 degrees (90 + 45) if you follow the angles given. You can certainly modify the seat angle if you like, but the angles given will offer a good balance of comfort and aerodynamics all around.

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Figure 79 – Mark a line 3 inches from the rear of the main boom tube

There will be a 3 inch section of the main boom (B) extending past the joint at the rear seat boom (A), which can be seen in Drawing 3 and Figure 85. This extended section is where the suspension pivot will join the rear frame section and allows room for a small gusset that will strengthen the frame for heavier riders. As shown in Figure 79, mark a line taken 3 inches from the rear end (90 degree end) of the main boom tube. I always mark “top” on the side of my tubing that does not have the seam so the seam is on the underside of the frame. Sometimes you can see the seam after painting.

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Figure 80 – Using a straight tube to align the frame for welding

The first two main frame tubes to join will be the main boom tube (B) and the seat back tube (A), forming the 135 degree seat angle. This tube is installed just ahead of the 3 inch line you marked in Figure 79 so that the 3 inch section will extend past the rear of the seat back tube. Use another section of 1.5 inch tubing or some thick angle iron to clamp the two tubes for welding as shown in Figure 80. With the guide tube and clamps in place, frame distortion will be eliminated, keeping the tubing perfect inline during the welding process.

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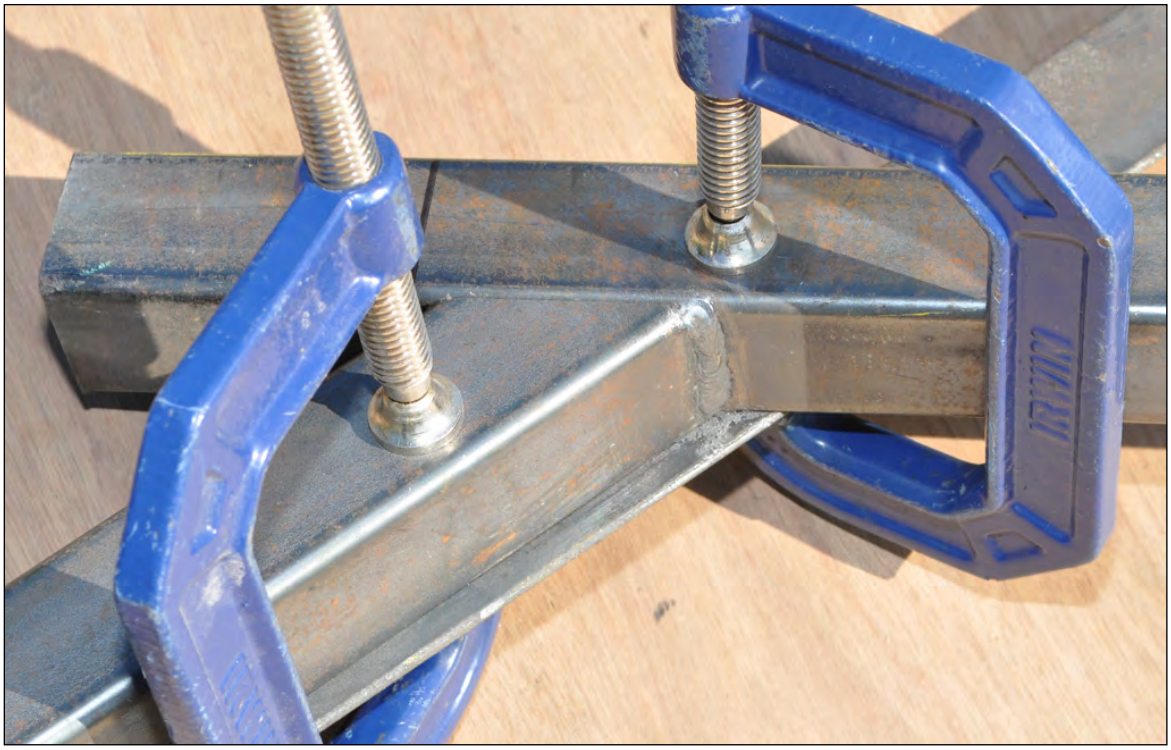

Figure 81 – Weld the top of the joint with the clamps installed

Using the usual order of welding, start with the top of the joint as shown in Figure 81 while the clamps are still holding the two tubes together. Keeping sided-to-side distortion to a minimum is important so that the front end of the frame will be inline with the rear of the frame.

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Figure 82 – Welding the two sides of the joint

With the clamp still installed, weld the open side of the joint and then remove the clamps to complete the other side of the joint as shown in Figure 82. The rear of the joint is not welded because there will be a gusset installed at that point later. Welding the rear joint would also be very difficult due to the steep angle.

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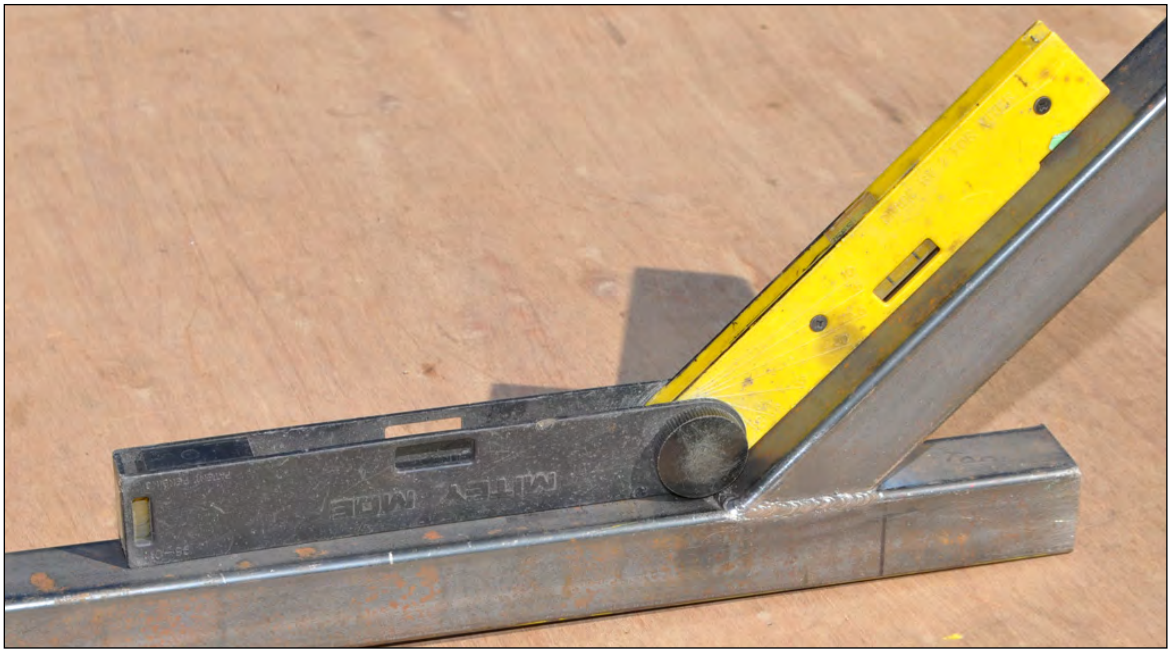

Figure 83 – Checking your angles is easy with an adjustable angle finder

When you are setting up angled joints for welding, an adjustable square (angle finder) is a great tool to have around. Check angles after clamping your work and after the first top weld has been made. There will still be a chance to adjust if necessary. None of the angles in this frame need to be absolutely precise, but try to stay as close to the goal as you can.

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Figure 84 – Using the clamps to install the front boom tube

The front boom tube (C) will now be installed to the front end of the main boom tube (B) as shown in Figure 84 and Drawing 3. Because both of these tubes are cut at 22.5 degrees from the end, the resulting angle will again be 45 degrees from the 90 degree (22.5 + 22.5) or 135 degrees in total, the same as the seat back tube angle.

Use the guide tube and clamps once again and repeat the same process to weld this joint as was done on the seat back tube. Figure 84 shows the top and bottom side of the joint welded first as the clamps hold the work perfectly inline.

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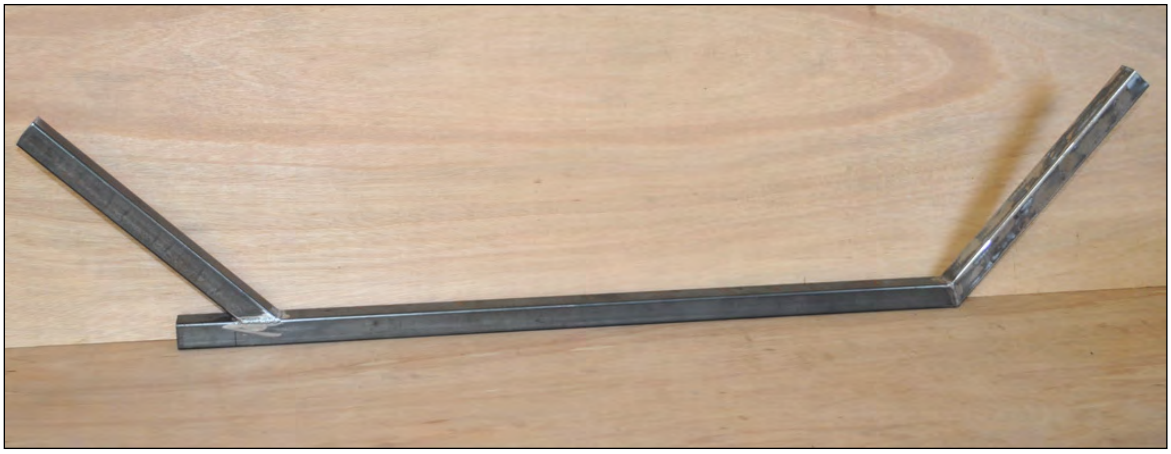

Figure 85 – The main section of the frame is now completed

Figure 85 shows the main frame section after welding the main boom tube (B), seat back tube (A) and front boom tube (C) together. This assembly will now look just like what is shown in Drawing 3. You can clean up the sides of the joint if you like, but avoid grinding the tops and bottoms of the joints too much as these are the welds that will carry all of the stress.

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JOINING THE REAR

Figure 86 – Setting up the main boom tube so that it is parallel to the ground

The rear frame assembly can now be attached to the front frame section by welding the suspension pivot to the rear section of the main boom as shown in Figure 86. From here, things become quite simple, as the shape of the rear section will dictate the height and ground clearance under the frame. The goal is to have the main boom tube (B) running parallel to the ground so that it continues a line formed by the tube at the rear of the frame that contains the suspension pivot bearing. The seat back tube (A) and front boom tube (C) must also be standing at 90 degrees to the ground, so the easiest method of achieving this is to set up the frame to the correct height as shown in Figure 86 so you can tack weld the pieces together right in place. I found a bucket and some scrap tubing to place under the main boom, holding it parallel to the ground at whatever height was necessary to form a line with the back section of the frame.

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Figure 87 – Using a level to verify the main boom parallel position

Figure 87 shows the main boom and rear section of the frame running parallel to the ground once propped up on 2 equal objects. If you want to check the position of the main boom, a level can be used to verify that the tubing is running parallel to the ground.

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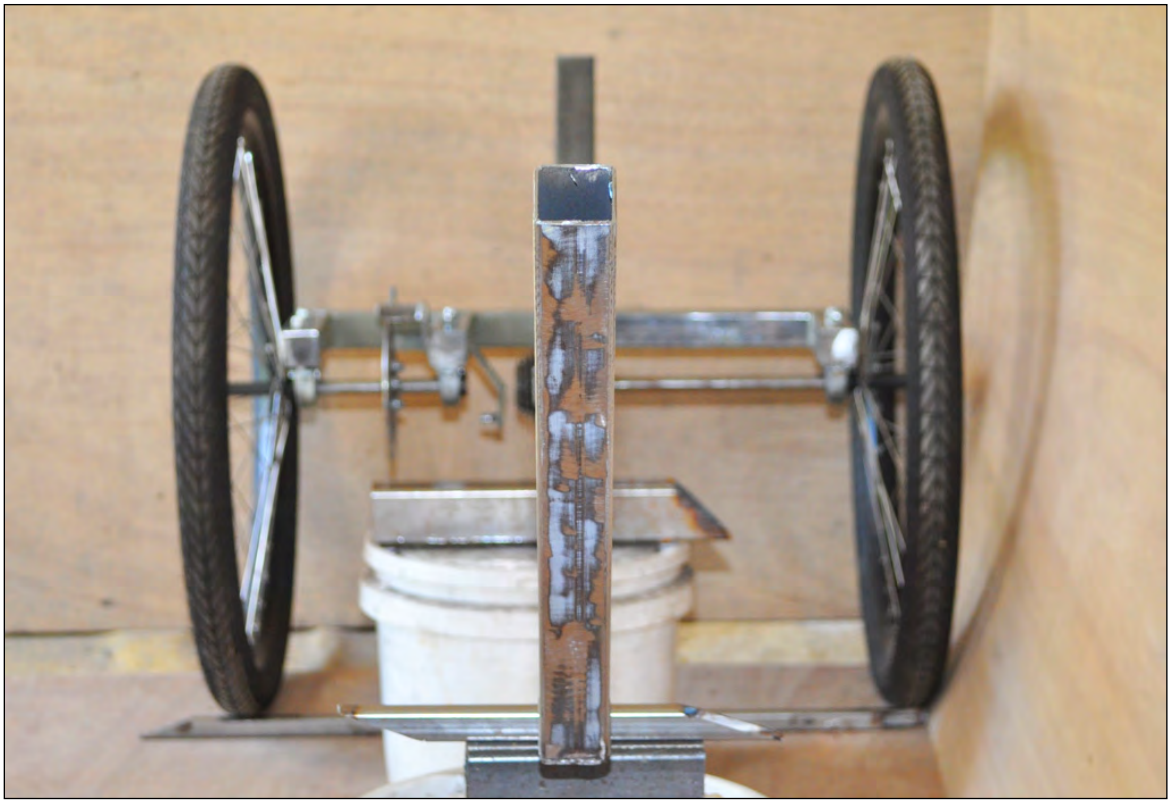

Figure 88 – The front boom tube must be at 90 degrees to the ground

Before making any welds, ensure that the front boom tube (C) is placed at 90 degrees to the ground as shown in Figure 88. Both tires should be inflated to the same level and all axle bearings should be secured. Look down the front of the frame and visually inspect the front boom tube to ensure that it is standing as straight as possible. If your level has a 90 degree face, it can be used to check these angles, but usually your eyes will be the best judge. If you find that the alignment between the rear seat tube and front boom are slightly off, use the front boom as the alignment tube as any error there will be seen much easier. The seat will hide any errors at the rear of the frame.

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Figure 89 – Tack welding the suspension hardware to the main boom

Once you have the frame set up and aligned properly, carefully add a few tack welds to the joint between the suspension hardware and the main boom as shown in Figure 89. Remember to check the 90 degree alignment of the front boom while you add the tack welds, as this will be difficult to correct later. Start with a tack weld at the top of the joint, check alignment, and then add one at each lower corner as shown in Figure 89.

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Figure 90 – Completing the suspension pivot joint welding

With the three tack welds holding the suspension part to the end of the main boom, you can carefully remove the pin from the pivot tube bearings and complete the welding around the rear of the main boom tube as shown in Figure 90. Again, weld the top and bottom side of the joint first and then complete the sides to avoid distortion.

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FRONT HEAD TUBE

Figure 91 – Cutting a head tube from an old bicycle frame

If you have not already chosen a front wheel and forks, then now is the time. Once again, you will need the tire installed and inflated on the rim. The TimberWolf can be made with a solid fork or a suspension fork, and requires a 20 inch wheel along with a set of 20 inch forks and matching head tube hardware. If you plan to use a front suspension fork, keep in mind that the upper portion of the crown needs to be steel not aluminum as you will need to weld to it later. Twenty inch suspension forks are not usually decent quality as they are mainly found on kids' bikes, and in reality, the rear suspension will take up most of the road shock due to the length of the main boom. Twenty inch rigid front forks are probably your best choice and certainly the best choice if you intend to add a front hub motor at some time.

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You will need a head tube that matches the stem length on your chosen front forks. It does not have to be from the same frame that the forks were taken as long as you can install the hardware and have the forks spin freely. If the threaded fork stem is a bit too long, it can usually be cut to length, and if the fork threads are too short, you can also trim the head tube to fit. Figure 91 shows the head tube I will be using, cut from an old scrap frame that was in my stock pile. Cut the head tube as close to the joint as you can, but avoid nicking the tube.

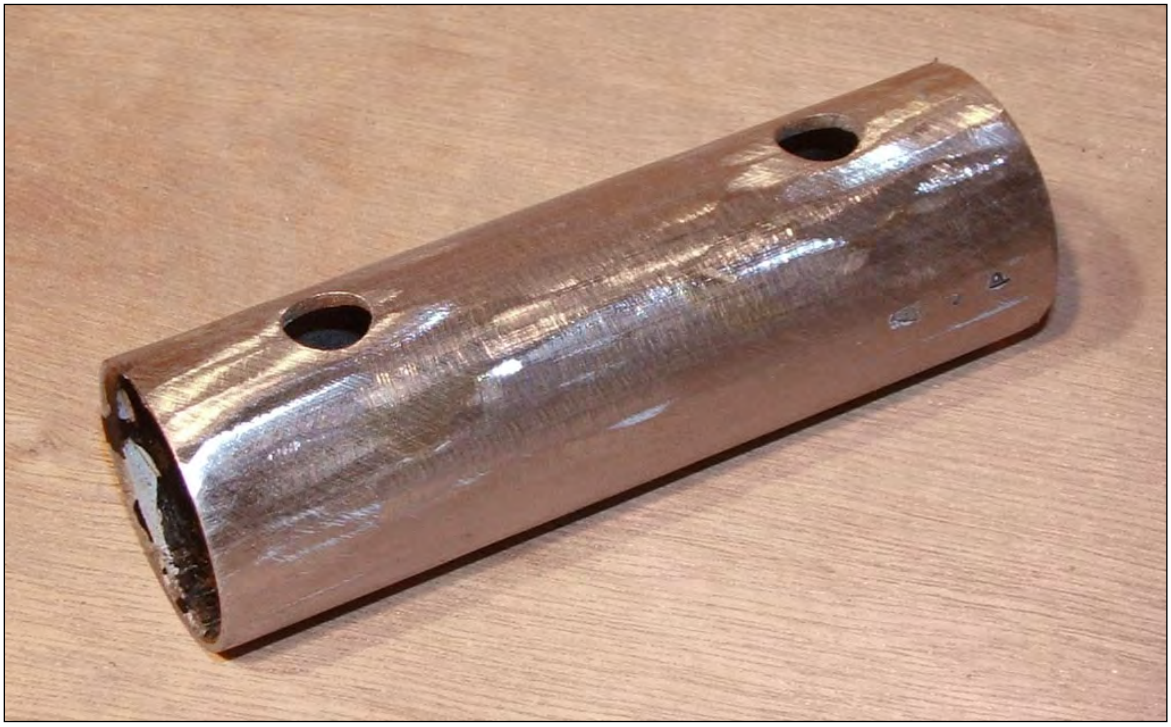

Figure 92 – Grind the head tube clean

The head tube is ground clean as shown in Figure 92 to remove all excess metal from the original frame tubing. A rough grinding disc makes easy work of cutting down the tubing and the flap disc makes the part look like new again.

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Figure 93 – The front forks and head tube hardware assembled

There are a few different sizes of head tube cups, so it is important to use a matched set of bearings and rings. If all of the parts came from the same bike, then you are all set. Remember that bearings go into the cups “balls first” and when all of the hardware is tight so there is no play, the forks should spin freely in the head tube. If there is any amount of friction, then either the bearings are in backwards or something is the wrong size. Figure 93 shows the head tube after grinding with the bearing cups, bearings, and top race installed for testing.

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HEAD TUBE ANGLE

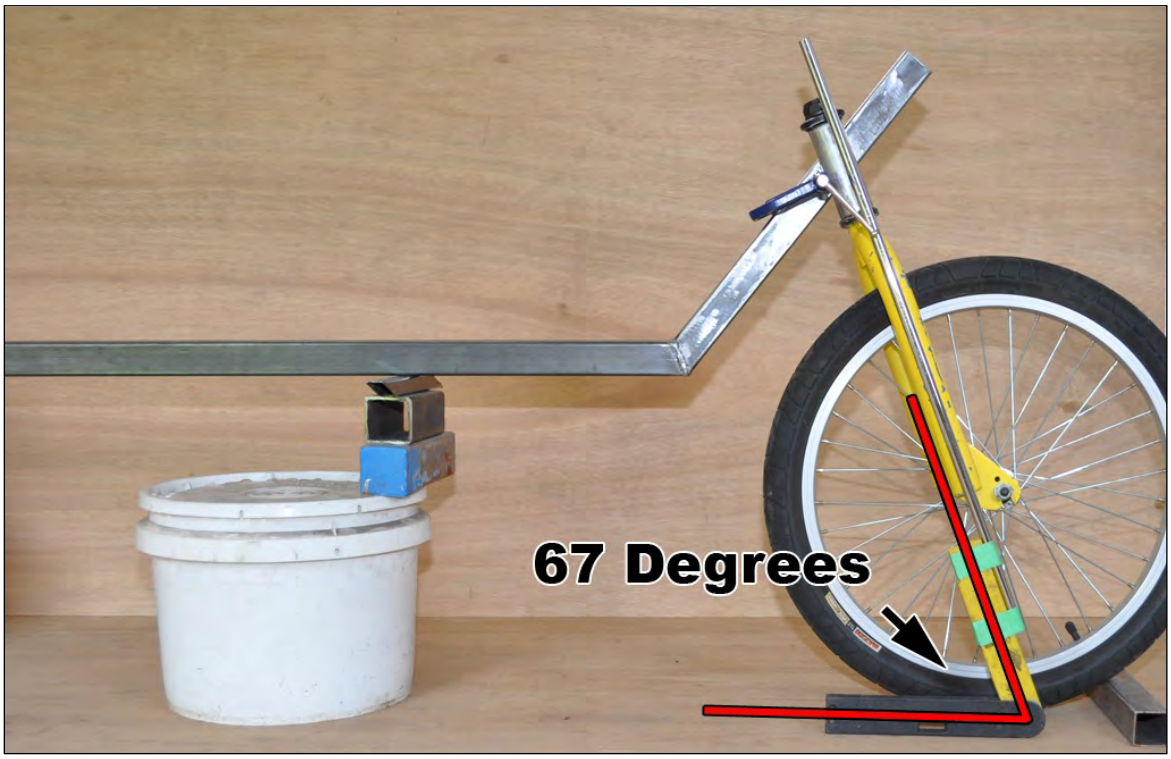

Figure 94 – Setting up the head tube angle to mark the boom for cutting

The head tube angle of a bike or trike refers to the angle between the head tube and the ground. To demonstrate this, a long metal rod is taped to an adjustable square which is placed flat on the ground as shown in Figure 94. The angle of the head tube on the TimberWolf will be 67 degrees as shown in Figure 94. If you do not have an adjustable angle finder, you can print out the 67 degree angle from any graphics program and then cut it out as a guide. Ultra precision is again not necessary, but try to get close.

As you can see in Figure 94, the front boom will need to be trimmed, and this was done intentionally so that variances in your tire size, fork size, and head tube could be accounted for. Once you have the 67 degree head tube angle set up with the front boom placed in the center of the head tube, you can easily mark a line to trim the front boom.

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A clamp placed on the front boom tube and a block for your front tire are used to set up the parts for marking.

Figure 95 – The head tube is resting on the front boom clamp

The front boom tube should be intersecting the head tube somewhere in the center as shown in Figure 95. It is not critical that there be equal distance on the top and bottom of the head tube, but the bearing cups should have at least enough room between their edges and the boom tubing so that a weld can be made.

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Figure 96 – Draw a cutting line in front of the head tube

The head tube will be sitting in a fish-mouth cutout made on the front boom, so a line must be drawn using the head tube as a guide so you can make the cuts and fish-mouths on the top and bottom of the tubing. Draw this line ahead of the front tube as shown in Figure 96, using the edge of the head tube as a guide to draw the line.

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Figure 97 – Transferring the line around the front boom tube

Once you have drawn the head tube cut line as shown in Figure 96, use a square to transfer this line around the tube as shown in Figure 97. By marking a 90 degree line at the top and bottom, you can then join them together on the unmarked side, completing the head tube cut line opposite the one you originally marked.

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Figure 98 – Use the head tube as a guide to mark the fish-mouth cut

The actual head tube will be used as a guide to trace the fish-mouth cuts to be made on the top and bottom of the front boom. As shown in Figure 98, the head tube is placed just behind the line you drew and a line is traced from edge to edge on the top and bottom of the front boom tube.

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Figure 99 – Showing how the head tube will fit into the front boom tube

Figure 99 shows how the head tube will be fit to the front boom tube once the fish-mouth cuts are made. A fish-mouth circle is traced on the top and bottom of the boom and then the boom is trimmed where the fish-mouth meets the side walls of the tube. This boom trimming line is the second line shown that meets the corners of the fishmouth circle.

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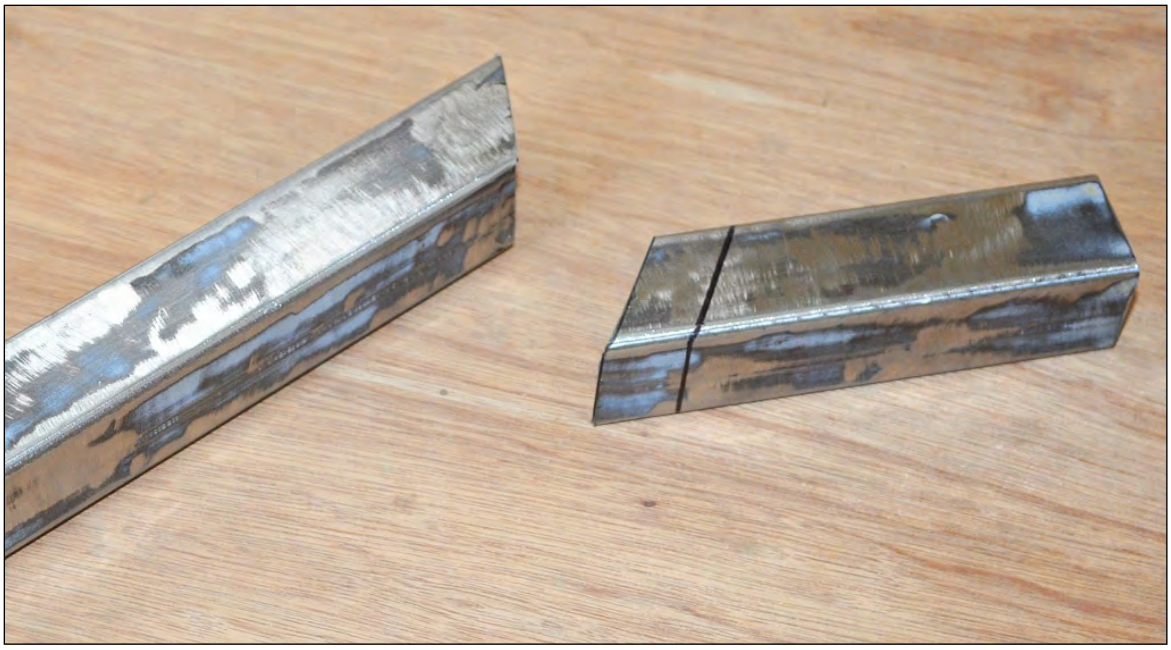

Figure 100 – Trim the front boom along the new cut line

The front boom is trimmed along the cut line that meets the edges of the fish-mouth cut as shown in Figure 100. The line shown on the leftover piece was the original line drawn along the head tube shown in Figure 96.

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FISH-MOUTH CUT

Figure 101 – Cutting out the two fish-mouth areas

Use a zip disc or hacksaw to rough cut the fish-mouth by cutting a triangle out of the tube as shown in Figure 101. This makes the final grinding easier as you only need to work to the line using a standard grinder disc or round file.

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Figure 102 – Keep the gap to a minimum so welding is easier

Take care on the fish-mouth cuts so that the head tube sits straight in the boom tube and so there is minimal gap in the joint. A round file is usually good for the fine tuning of the joint once the initial rough grinding has been completed.

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Figure 103 – Setting up the frame and head tube for welding

With the fish-mouth cuts made, place the frame back up so the main boom is parallel to the ground and then sit the head tube back into the fish-mouth joint as shown in Figure 103, using a wedge in front of the tire to hold it in place. The head tube will be tack welded in place right here, which will take care of any alignment problems that may have occurred during the main frame welding. The goal is to have the head tube installed at the correct 67 degree angle and standing perfectly straight up (90 degrees) from the ground.

If you find that the front forks are moving around in the head tube, remove the top bearing and then screw the race down tight. This will stop them from turning as you carefully set up the parts for tack welding. Visually inspect the frame from the front so you can ensure that all three wheels are standing up at 90 degrees from the ground.

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Figure 104 – Tack weld the top of the head tube and the two side corners

Make a tack weld on the top of the joint as well as the two side corners once you have the alignment of the head tube set up properly. Double check the angles from all sides of the trike as you add the tack welds. Once the three tack welds are securing the head tube to the front boom (Figure 104), carefully remove the forks and so the joint can be fully welded.

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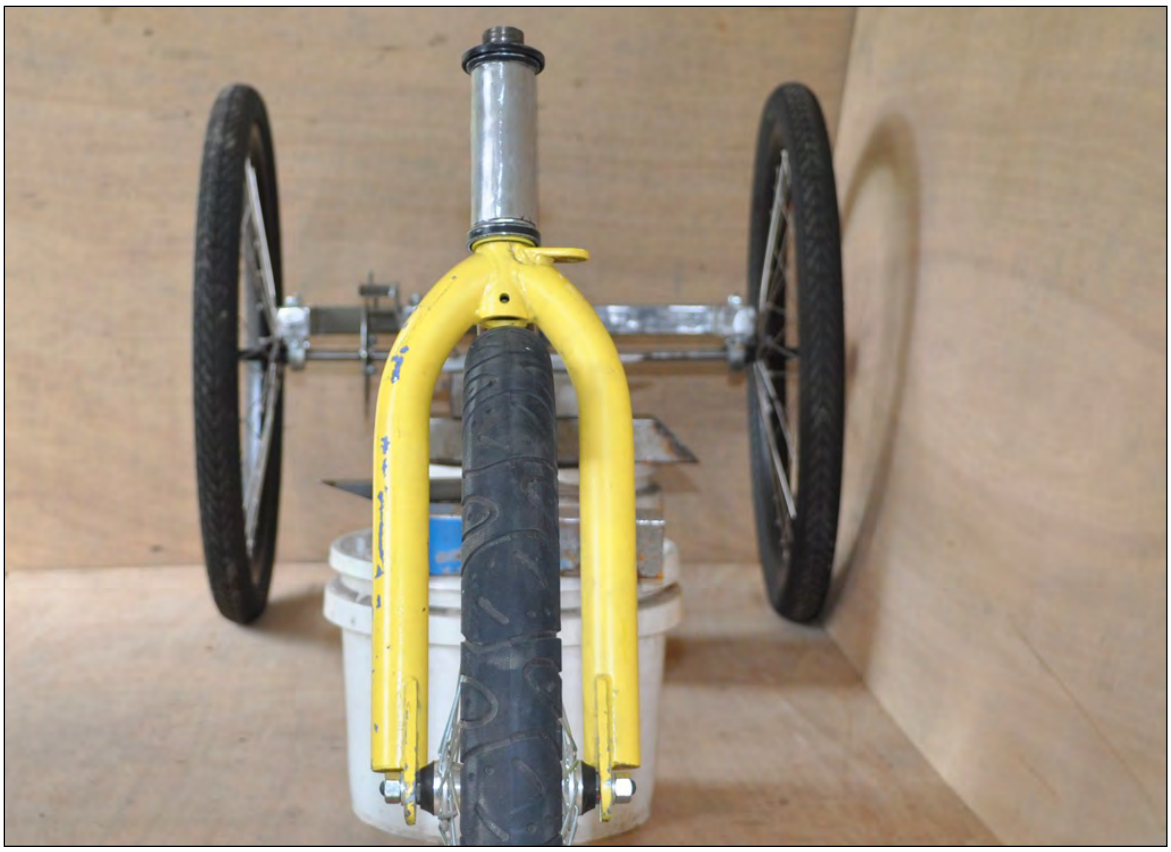

Figure 105 – Ensure that all three wheels are standing at 90 degrees to the ground

Figure 105 shows how the trike should look as viewed directly from the front. All three wheels and the head tube should be standing at the same angle, 90 degrees from the ground. Any errors in the frame will be corrected here since it is the wheel alignment that counts.

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Figure 106 – Weld the top and bottom of the head tube joint first

Like all of the other angle critical joints, the head tube joint must be welded in the correct order to keep heat distortion to a minimum. The top and bottom side of the joint are welded first. To prevent the head tube from becoming slightly oval, have the bearing cups installed as you weld as shown in Figure 106.

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Figure 107 – The sides of the head tube joint are completed last

Once the top and bottom of the head tube joint are welded, you can safely finish the welding on the sides of the joint as shown in Figure 107. It doesn't hurt to double check the alignment one last time before welding the sides just in case something has gone wrong.

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SUSPENSION SYSTEM

Figure 108 – Testing the suspension spring on the frame

The position of the suspension spring on the frame as well as the weight of the rider will affect how stiff or smooth the suspension feels. It's a good idea to do some actual testing with your own suspension spring by placing a few clamps to hold the spring in place as you sit on a temporary seat. Most springs will be marked for 500 or 600 pounds of pressure and they all have an adjustment ring to fine tune the amount of initial resistance in the spring.

I found the optimal position of the spring was 7.5 inches behind the center of the pivot tube, leaning forward at about 45 degrees. I weigh 170 pounds, and my spring had a sticker that claimed it was rated for 650 pounds of compression. Moving the spring close to the pivot point means that your suspension will be softer since it will take less weight to compress the spring and moving the spring further back means that the spring will tolerate more weight, giving a more rigid feel. This of course, all depends on your

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own weight. You will have the chance to play around with the optimal spring position in the next few steps.

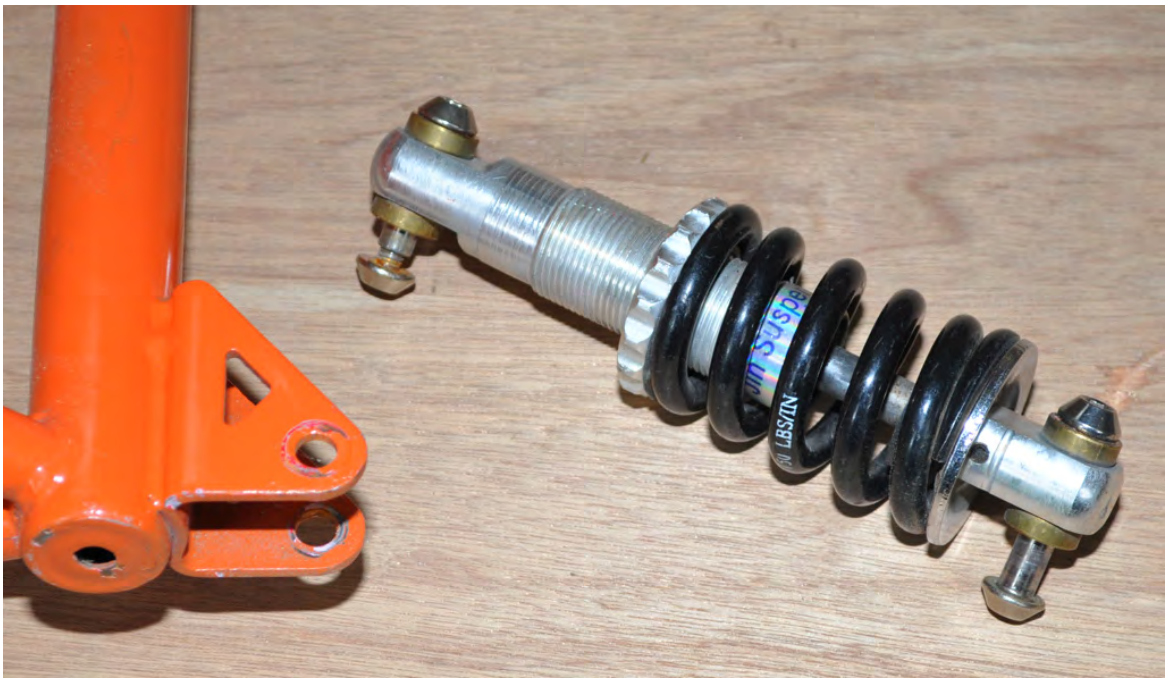

Figure 109 – You will need a set of spring mounting tabs

The suspension spring is held in place by a pair of mounting tabs like the set shown on the rear triangle in Figure 109. You can either salvage these mounting tabs from an old suspension frame or simply make your own by cutting four triangles from a bit of 1/8 inch thick flatbar. For my build, I salvaged the set shown in the photo and made the second set from some flatbar.

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MOUNTING TABS

Figure 110 – Cutting the suspension mounting tabs from the frame

The suspension mounting tabs shown in Figure 110 are the optimal type to salvage from a frame because they will come off in once piece. Some frames have two separate tabs welded to the frame tubing, so you will need to cut them both and then grind them to ensure that they are exactly the same size.

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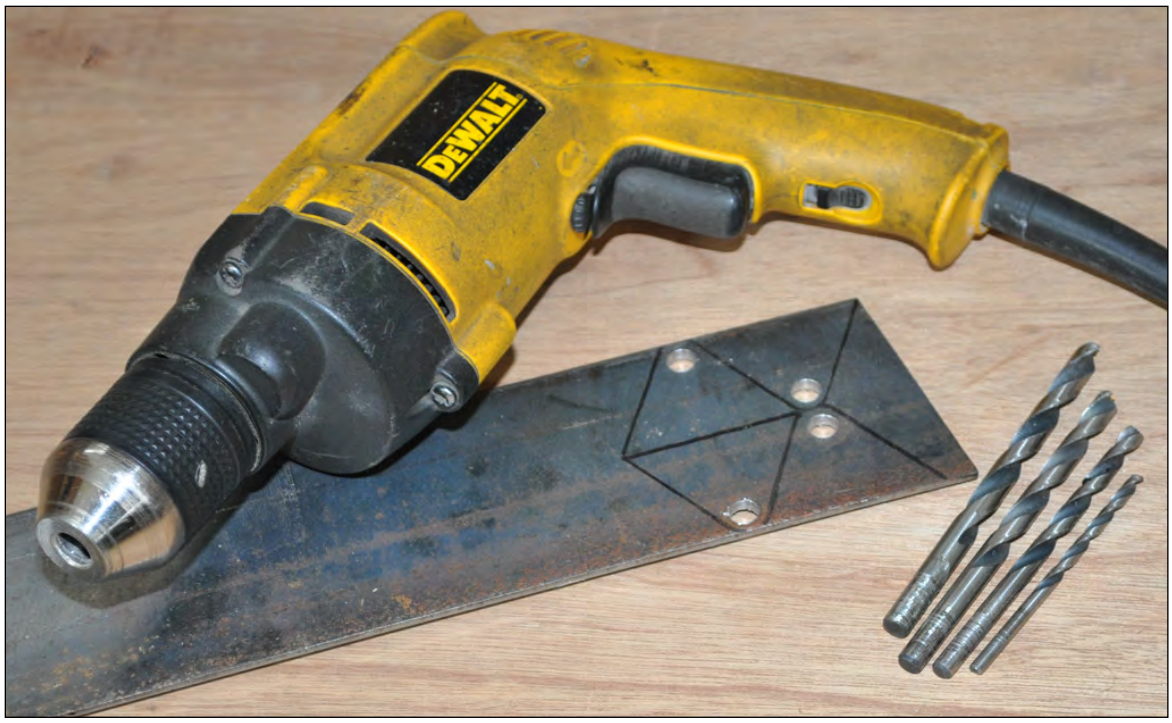

Figure 111 – Creating suspension tabs from flatbar

To make your own suspension spring mounting tabs, draw a set of triangles onto some 1/8 inch thick or slightly thicker flatbar as shown in Figure 111. A triangle with a base of 2 inches and a height of about 1.5 inches will be perfect. It is also easier to drill the holes before cutting so you have something to hold while you drill. To drill an accurate hole, start with a small bit and work your way up to the required size, which will likely be 5/16 for most suspension spring bolts.

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Figure 112 – Cleaning up the handmade mounting tabs

It is important that your suspension spring mounting tabs be of equal size, so align them by the drill hole in a vice and then grind them together to make them exactly the same shape (Figure 112). Take off sharp edges using a sanding disc.

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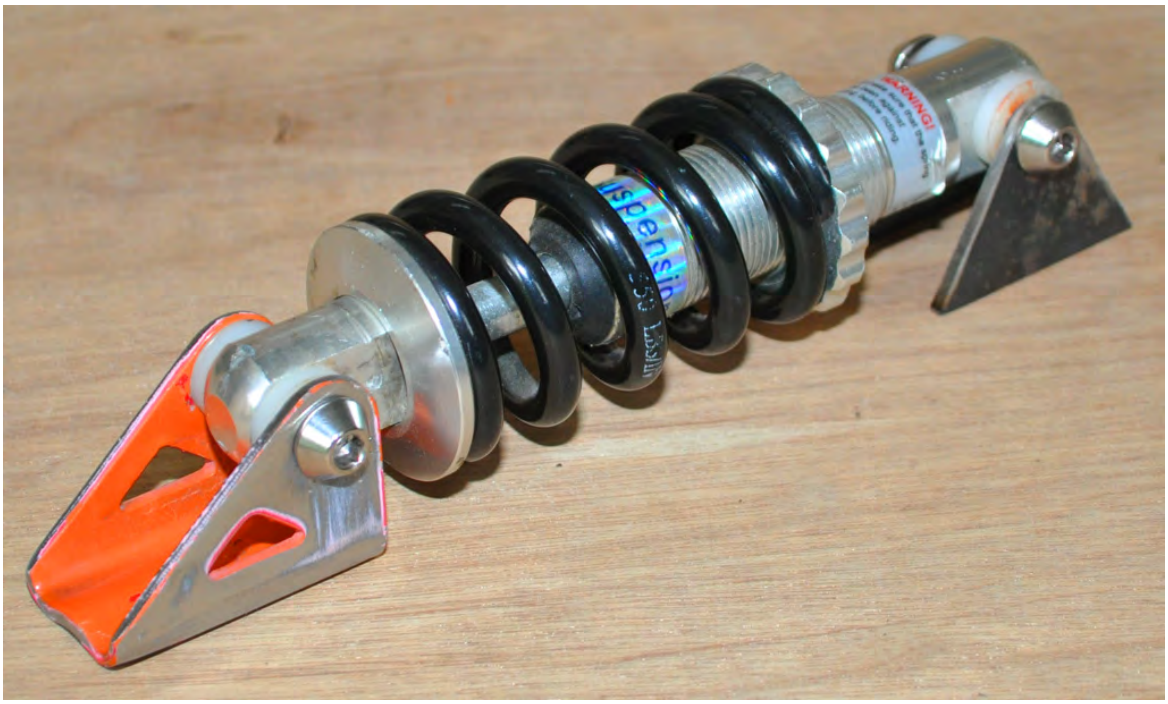

Figure 113 – The suspension spring ready to be mounted to the frame

With both sets of suspension spring mounting tabs completed as shown in Figure 113, you will be ready to mount your suspension to the frame. Install the bolt hardware so that all parts are tight and ready for installation.

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SPRING INSTALLATION

Figure 114 – Installing the suspension spring on the frame

For most installations, the suspension spring can simply be places at a 45 degree angle on the frame as shown in Figure 114, which will put the lower bolt about 7.5 inches away from the center of the pivot point bolt. This configuration will be fine for riders weighing between 120 and 200 pounds as the spring itself can be adjusted later on by turning the tensioner ring. The installation of the suspension spring is done with the frame sitting parallel to the ground so that with no weight on the bike, both the main boom and rear tubing are sitting parallel to the ground. With a rider in the seat, the spring will only compress slightly.

Test the spring before welding the mounting tabs by clamping them to the frame as shown in Figure 114. If you sit on a board placed on the boom, the frame should only dip slightly, but a good bounce should make the spring move an inch or so. If your weight compresses the spring more than half an inch, then you may need to adjust the spring

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tension using the adjuster ring or try to fit the mounting tabs further back from the pivot point, which will require some tubing or flatbar to make the top tabs longer in order to make up the gap. In an extreme case where rider weight seems to compress the spring a lot, a second spring can be added, placing one beside the other. Two springs would be necessary if rider weight was to exceed 300 pounds.

Figure 115 – Tack weld the suspension spring mounting tabs to the frame

Tack weld all of the suspension spring mounting tabs to the frame in the optimal place and then use a temporary seat to check the function of the spring one last time. If you bounce, the spring should respond with up to an inch of travel, but if you sit still, the spring should be only slightly compressed or not at all. If you spring compresses more than half an inch while you are sitting still, try the adjuster ring or re-think the position of the spring on the frame. Also, avoid any heavy welding with the spring installed as the plastic bushing will melt. A quick tack weld is ok, but let the tabs cool before making another.

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Figure 116 – Welding the suspension spring mounting tabs to the frame

Once you are happy with the feel of your suspension, you can completely weld the mounting tabs to the frame as shown in Figure 116, welding a bead on the outer side of the joint only. Do not weld with your suspension spring installed or the plastic bushing will melt down to nothing and you will have to find a new spring.

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Figure 117 – Adding the rear gussets to the frame

To complete the frame and give strength to the most load critical joint, a pair of 2 inch triangle gussets should be added to the joint behind the seat tube as shown in Figure 117. This is done because the joint at the far rear has not been welded, so the gussets will add great strength to this part of the frame. Any 1/8 inch thick flatbar or steel will work fine.

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Figure 118 – The TimberWolf bare rolling chassis

Congratulations, you now have a rolling chassis! It won't be long before your trike is ready to ride. The rest of the building process will be smooth sailing.

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MAKING THE SEAT

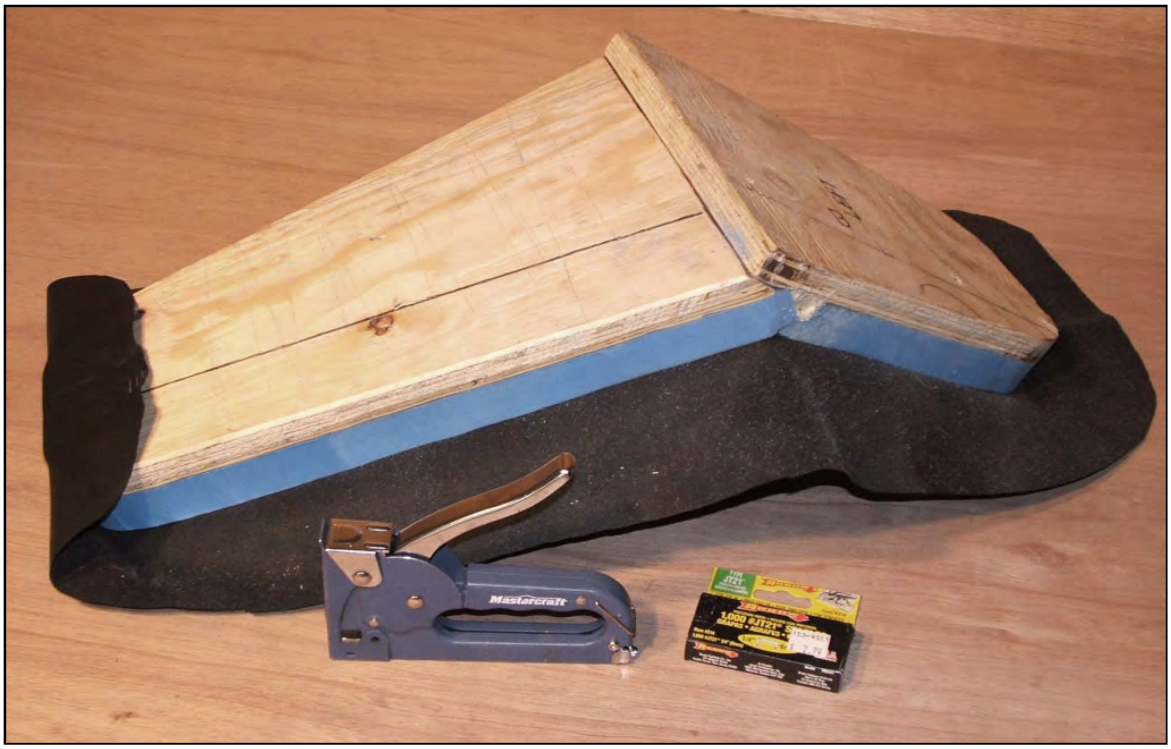

Figure 119 – Creating a simple wood and foam seat

The seat shown being made in Figure 119 is made by bolting two half inch thick plywood boards together at the center using a pair of shelf brackets. One inch or slightly thicker dense foam is then glued to the wood and trimmed around the edge using a knife or the angle grinder. The seat is covered with either spandex or some kind of vinyl to make it resist moisture and wear. The seat can be made to whatever width you like, but remember that the under seat steering handlebars have to find their way around the base of the seat. You may want to complete the steering before making your final seat.

I usually use the same basic seat dimensions, which are as follows: the bottom is 10 inches square, tapered to 6 inches at the front and the back is 15 inches tall, tapered from 10 inches to 6 inches as well to match the bottom. A separate back rest is then made (shown later) as it is easier to make small comfort adjustments this way.

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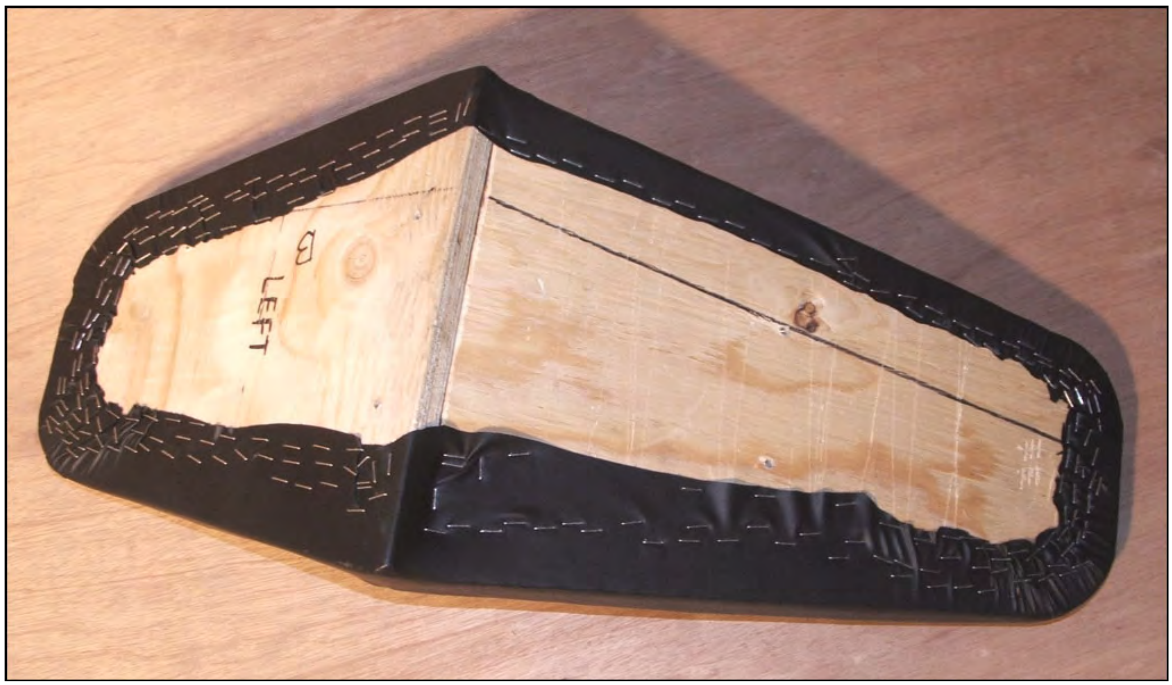

Figure 120 – Staple the seat material to the back of the wood

To make a covered seat with as few wrinkles as possible, start at one end and then keep stretching and stapling material as you work around the seat. You will not be able to get all of the wrinkles out like this, but you can get fairly close and end up with a very nice looking seat that doesn't cost you a fortune. Sometimes when stapling around the material, it helps to lift up some of the staples if a wrinkle seems large in that area. Figure 120 shows the result of about 20 minutes of material stretching and stapling.

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Figure 121 – Staple the seat material to the back of the wood

To cover up the visible rear portion of the seat where all of those staples live, a cover can be made by cutting out the required shape from a plastic bucket as shown in Figure 121. Upholstery tacks can be used to fasten the cover to the wood back.

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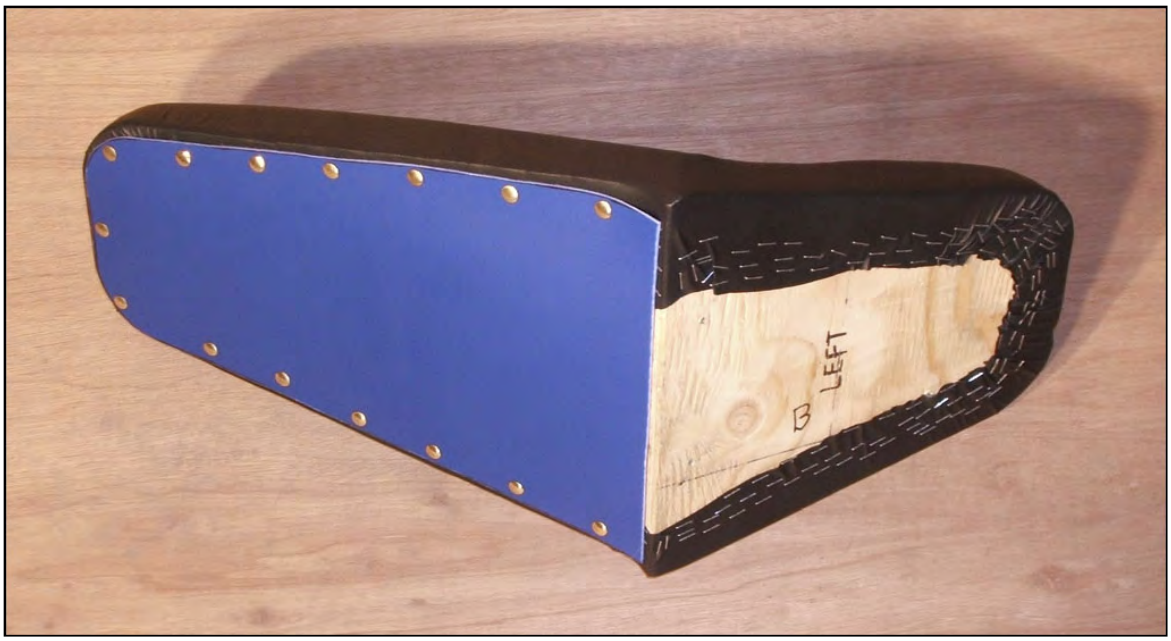

Figure 122 – Installing the rear cover that will hide the ugly staples

Figure 122 shows how the plastic backing is installed over the stapled area, using several thumb tacks to fasten it to the wood. The completed seat will look close to factory made once installed, which is not bad considering it cost only a few dollars to create.

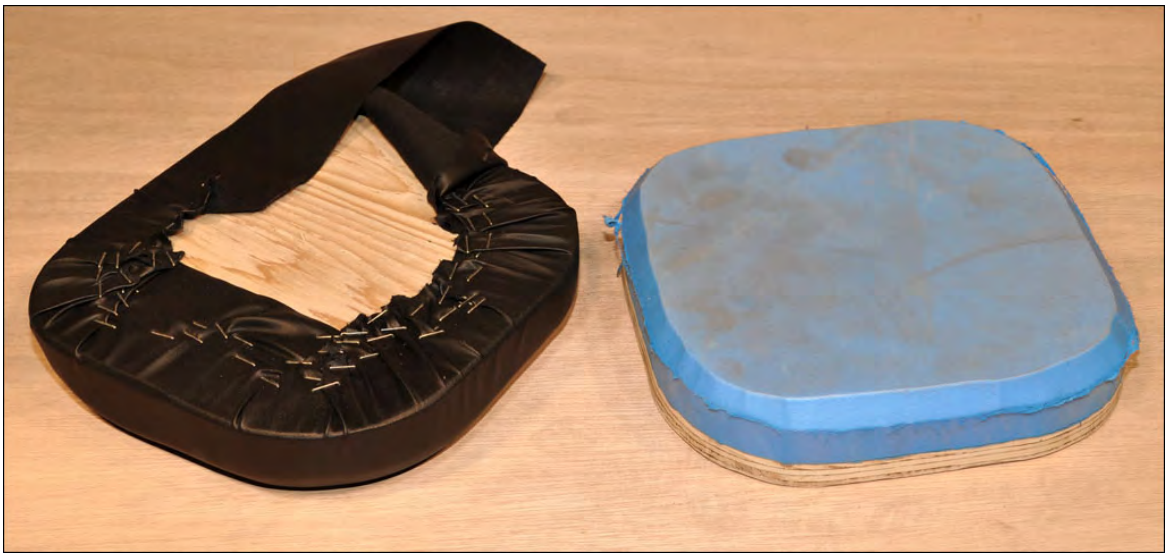

Figure 123 – Making a back rest using the same techniques

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For maximum comfort, an upper back rest will also be added to the seat, and this 8 inch square part is made using the same wood, foam, and material as the rest of the seat. Since it's visible from behind, the rear of the back rest will also get a plastic cover to hide the stapled area. Feel free to alter your seat design to suit your needs.

Figure 124 – Adding the decorative cover to the back rest

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SEAT RISER

If you find that the plastic is slightly translucent and not completely hiding the staples and wood, paint the area black as shown in Figure 124 and then the cover will completely hide all of the rough area underneath.

Figure 125 – The seat riser tube will lift the base of the seat slightly

Since the main boom is completely parallel to the ground, the base of the seat needs to be lifted slightly to give a more secure feeling when piloting the TimberWolf. A completely parallel seat would allow the rider to slip forward under hard braking and would not seem as comfortable as a seat that is lifted slightly at the front of the base. The ¾ inch wide square tube shown in Figure 125 will double as a seat riser as well as a place to fasten the seat base to the frame.

The seat riser tube is 5 inches long and made from ¾ inch wide square tubing or even angle iron. The ends have been cut to 45 degrees so that it is easy to install a pair of woodscrews at the end of the tube in order to fasten the wooden seat base.

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Figure 126 – The seat riser tube sits under the front of the seat base

To lift the seat slightly, the seat riser tube will be placed about 2 inches from the end of the seat base on the main boom tube as shown in Figure 126. Having the seat base lifted slightly is more comfortable than a flat seat and it also gives the chain and steering bits a little more room to live under the seat.

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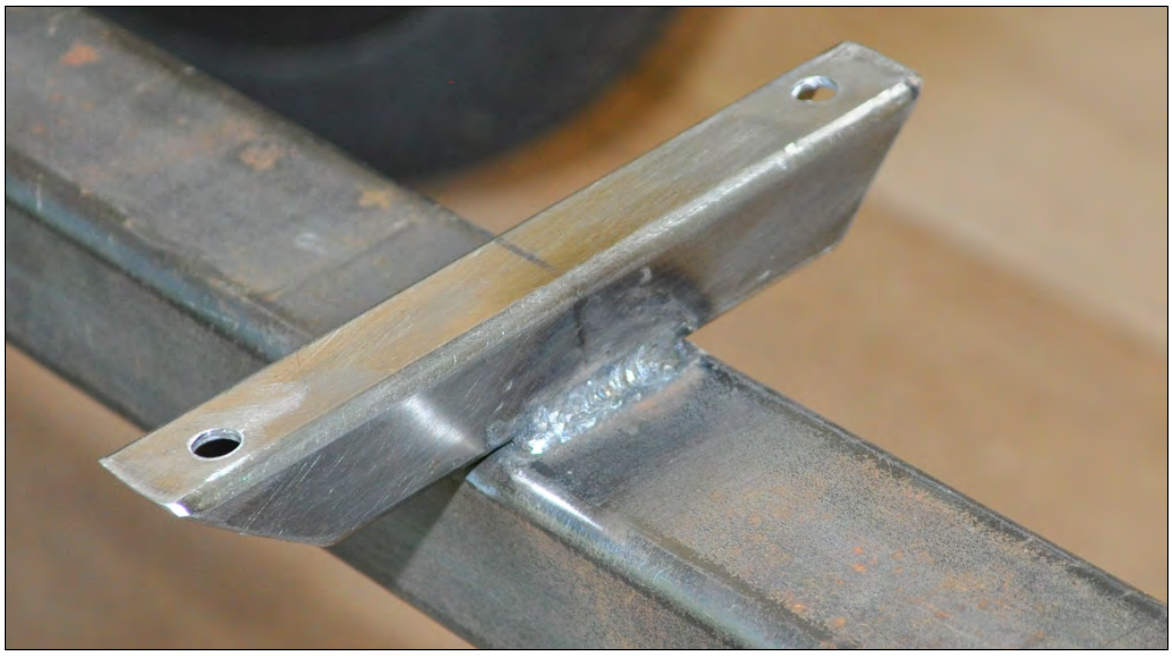

Figure 127 – The seat riser is welded across the main boom tube

Weld the seat riser tube across the main boom as shown in Figure 127. If you plan on experimenting later with your seat shape and angle, then just tack weld it in place for now and complete the welding after the steering and transmission parts are installed.

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Figure 128 – The seat riser tube will lift the base of the seat slightly

The back of the seat will be fastened to the rear seat tube using a pair of 2 inch tabs as shown in Figure 128. These are placed so that they are about midway up the seat back and drilled for a pair of woodscrews. 1/8 inch thick flatbar with a width of 1 inch or 1.5 inches is just fine.

Figure 129 – Adding a top cap to the open end of the seat tube

The back rest portion of the seat will sit at a much steeper angle than the back of the seat and will be installed over the top of the seat back tube. For this reason, a cap must be made for the open end of the seat back tube as shown in Figure 129. This cap is made using the same methods as the three caps on the axle support frame tubes.

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BACK REST SUPPORT

Figure 130 – Installing the back rest support tube

The angle of the back rest portion of the seat is completely up to you, and should be found by sitting in the seat while a helper holds the back rest firmly in place. As seen in the completed TimberWolf photos, I found the optimal position of the back rest to be just a few degrees back from almost 90 degrees. You can leave this part for later as well.

The back rest support tube is another short length of ¾ inch wide square tubing that is welded directly to the cap on the end of the seat back tube as shown in Figure 130. The end has been cut at 45 degrees so a woodscrew can be used to fasten the back rest in place. There is another hole drilled through the midpoint of the tube for a second woodscrew.

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ADJUSTABLE BOTTOM BRACKET

Figure 131 – Making an adjustable bottom bracket

The TimberWolf includes an adjustable bottom bracket so that riders of varying leg lengths can adjust the distance between the seat and pedals for optimum comfort and performance. Moving the bottom bracket is more practical than moving the seat because the steering system would also have to move with the seat, creating a very complex and difficult design to adjust linkage system. By moving the bottom bracket, we only have to deal with the front derailleur, which just happens to be part of the sliding bottom bracket, so adjustments can be made easily. Any difference in chain length can be taken up by the rear derailleur's spring mechanism, so the entire process is painless and easy.

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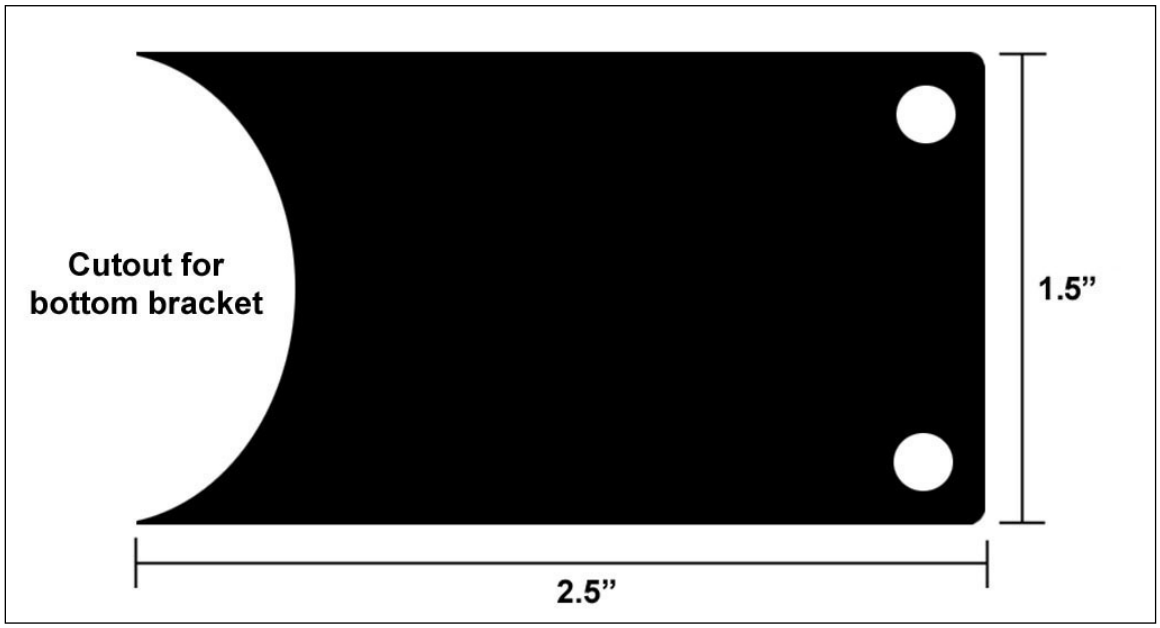
Since the front derailleur requires a length of the seat tube to hold the clamp in place (as it did on the original bicycle frame), we will leave a bit of this tubing when we cut away the bottom bracket from the scrap bicycle frame as shown in Figure 131. Cut the chain stays and down tube from the bottom bracket and leave at least 12 inches of the seat tube intact, so you will have plenty of room to place the derailleur no matter what type of front chain ring you plan to install. The extra length of seat tubing will be cut away once you have the front derailleur in place.

The bottom bracket and included seat tube will be mounted to the main boom with a clamp arrangement that allows the assembly to be placed practically anywhere on the boom to allow riders of varying heights to ride the bike. The two plates shown in Figure 131 will form the sides of the clamp that will hold the bottom bracket against the side walls of the main boom as they are forced together by two bolts.



Drawing 5 – Adjustable bottom bracket clamps

The bottom bracket and front derailleur tube move together along the main boom, so you do not need to worry about the position of the derailleur over the chain ring. The chain is cut to the perfect length once the bottom bracket has been adjusted for the main rider, but will still allow a few inches of adjustment in either direction without a chain alteration due to the spring loaded rear derailleur. Of course, the

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difference between a 6 foot 5 inch adult versus a 4 foot tall child will likely require some chain adjustment, but this can be changed in minutes with an inexpensive chain link tool.

Cut two 3/16 inch thick pieces of plate or sheet to make the shapes as shown in Drawing 5. The round area is cut to conform to whatever size bottom bracket you decide to go with, and the two bolt holes will be drilled for 1/4 inch bolts. The bolt holes are drilled at the edge of the plates so that there is 1/8 inch of material between the hole and edge of the plate. These two plates will form a "vice" that will clamp the bottom bracket to whatever position on the main boom you want.

Figure 132 – Fish-mouth cuts for the bottom bracket

Trace around the bottom bracket shell to draw a line on the plate as shown earlier in Figure 131. The marker line should meet the corners of the plate to ensure that you don't cut out too much off of the plate when grinding out the rounded area. If you

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take too much metal away from the plate, there will not be enough room between the bottom bracket and the clamping bolts for the main boom.

When grinding out the traced circular area for the bottom, place both plates in the vice so that they can be done at the same time. This will ensure that both plates are exactly the same size. Try to make the gap as small as possible around the bottom bracket shell so that there is less distortion as the plates are welded. If the bottom bracket becomes overly distorted, it will be a serious challenge trying to screw the hardware back into the bottom brackets without stripping the threads. The completed plates are shown in Figure 132 after grinding them to be exactly the same.

Figure 133 – Aligning the two plates

To get the two plates aligned with each other and at the correct spacing, a bit of frame tubing can be clamped between the two plates as shown in Figure 133. This will allow you to set the bottom bracket into the correct position for tack welding and ensure that both plates are aligned with each other so the bolt passes easily through both holes. I also placed a sheet of paper (folded in half) between each plate and the side wall of the tubing to allow a little clearance between the clamp plates so that the unit is not too

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difficult to slide when making adjustments. Without the small gap, it is easy to scratch the paint if you plan to adjust the bottom bracket around a few times.

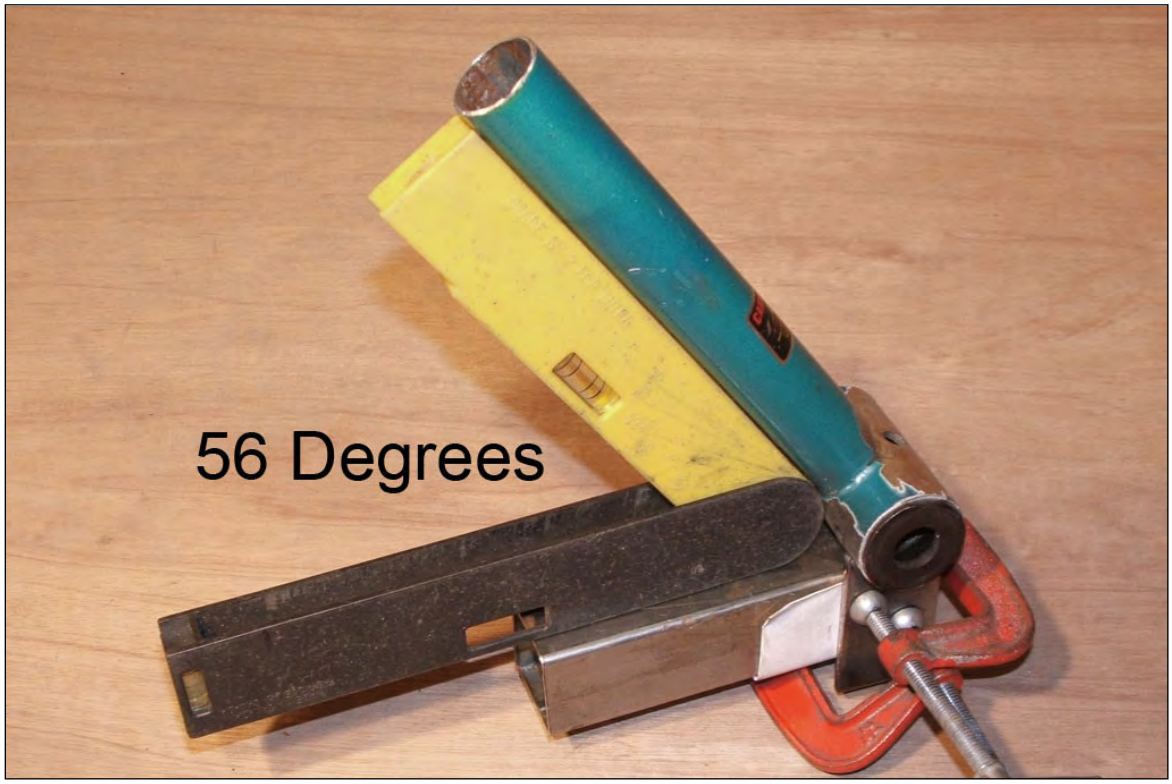

Figure 134 – The front derailleur tube angle

As shown in Figure 134, I used an adjustable square set to the required 56 degrees in order to set up the bottom bracket and derailleur tube to place two small tack welds at the top of the joint. It may be a bit tricky to get the first tack weld in place while holding the bottom bracket in position, but once this is done, the rest is easy.

With the piece of frame tubing as a guide, you will automatically have the correct distance between the plates. Now, you will need to ensure that there is approximately equal distance between each plate and the edges of the bottom bracket. In other words, the bottom bracket will be in the center of the main boom as viewed from above.

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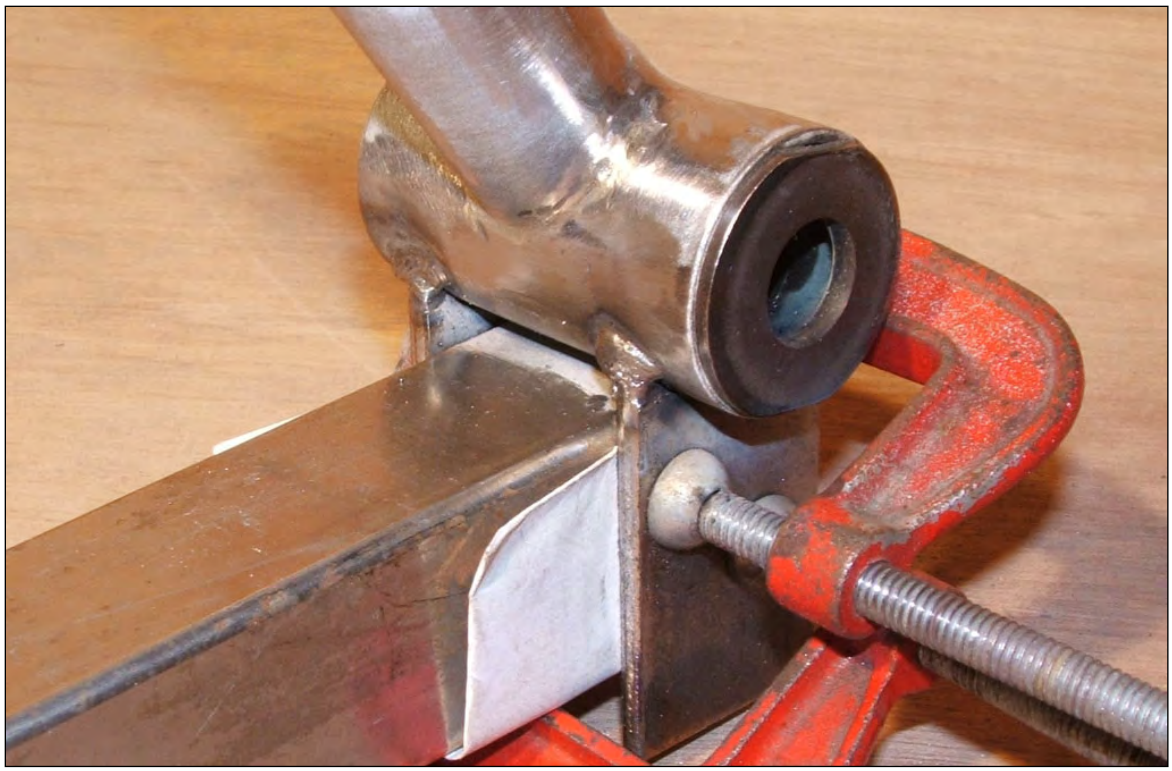

Figure 135 – Tack weld the bottom bracket plates

Figure 135 shows the first tack welds done at the top edge of the clamp plates to secure the parts together. Ensure that the derailleur tube angle is close to 56 degrees and that the bottom bracket is at 90 degrees to the square tubing. Welding is only done on the outside of the joint, not between the plates. If the inside of the joint is welded, the weld bead will not allow the bottom bracket to sit directly on the frame tubing and could cause alignment problems. Because of the way the clamp system works, there would be no added benefit from welding the inside of the joint anyway.

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Figure 136 – Mark a line to drill the bolt holes

The two plates will form a vice-like grip on the frame tubing when the 1/4 inch bolts are tightened. To drill the holes into the plate, draw a line that represents the bottom corner of the frame tubing as shown in Figure 136. Now, you can punch and drill the holes using the line as a guide that will allow you to make sure the holes stay below the line. If the holes are not below the line, you will not be able to pass the bolts through both plates because they will hit the frame tubing instead.

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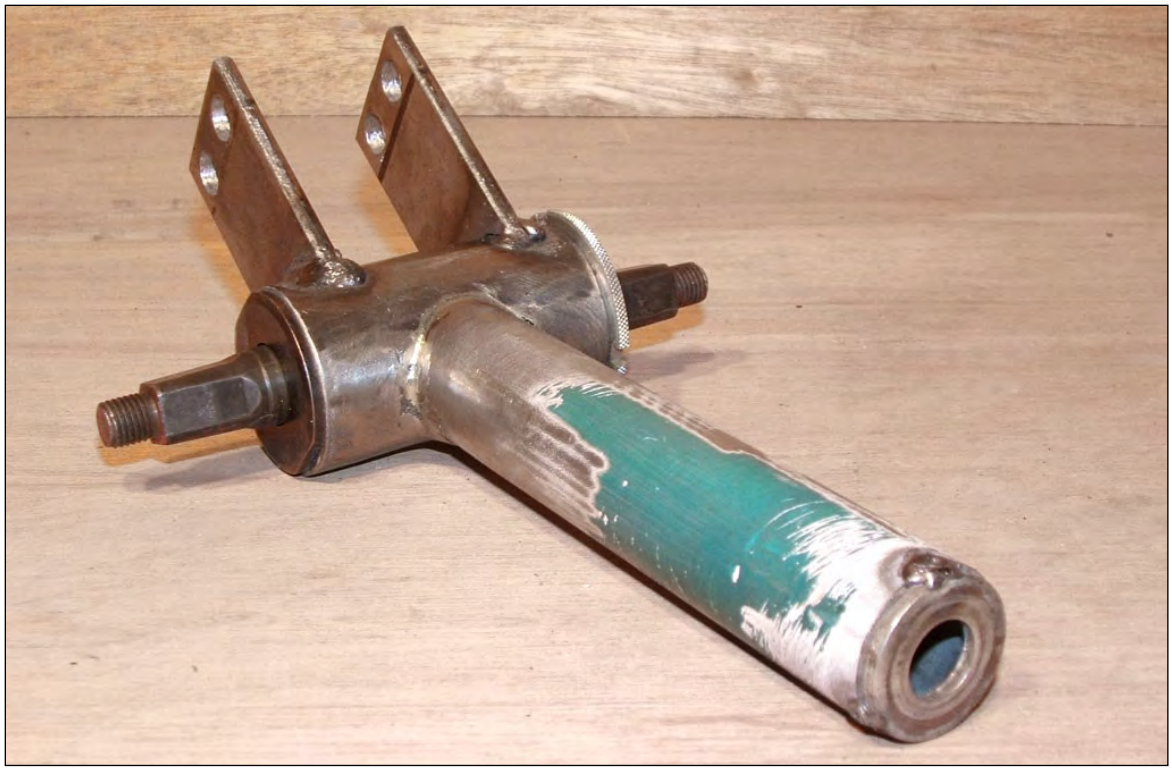

Figure 137 – Capping off the open tube

Later on when you have you chainring and front derailleur installed and tested, it is a good idea to cap off the open end of the tubing so that it looks better and keeps moisture out. As shown in Figure 137, a washer is welded over the end of the tube and then completely filled in around the joint and the hole. To fill in the washer hole, several passes are made around the edge until completely covered in weld metal.

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Figure 138 – Adjustable bottom bracket completed

After welding the washer in place and grinding the area clean, you can't even tell the tube shown in Figure 138 once had an open end. Going the extra distance can make your final product look very professional, possibly even better than some mass produced machines that have plastic plugs shoved into the open ends of the tubing.

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Figure 139 – The adjustable bottom bracket and crankset installed

Once the sliding bottom bracket assembly is installed on the frame, add a set of cranks and determine the optimal place to lock down your bottom bracket. Your knees should not lock completely straight out when pedaling, but you should be extending your legs close to the limit when pedaling. It is a good idea to find this magic spot and then measure the distance from the front of the frame to the edge of the sliding bottom bracket so that after you paint the frame, you won't have to scratch the paint while hunting for the optimal bottom bracket position again. The nearly completed TimberWolf shown in Figure 139 is really starting to look like something. Only the transmission system and steering components remain to be done now.

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TRANSMISSION SYSTEM

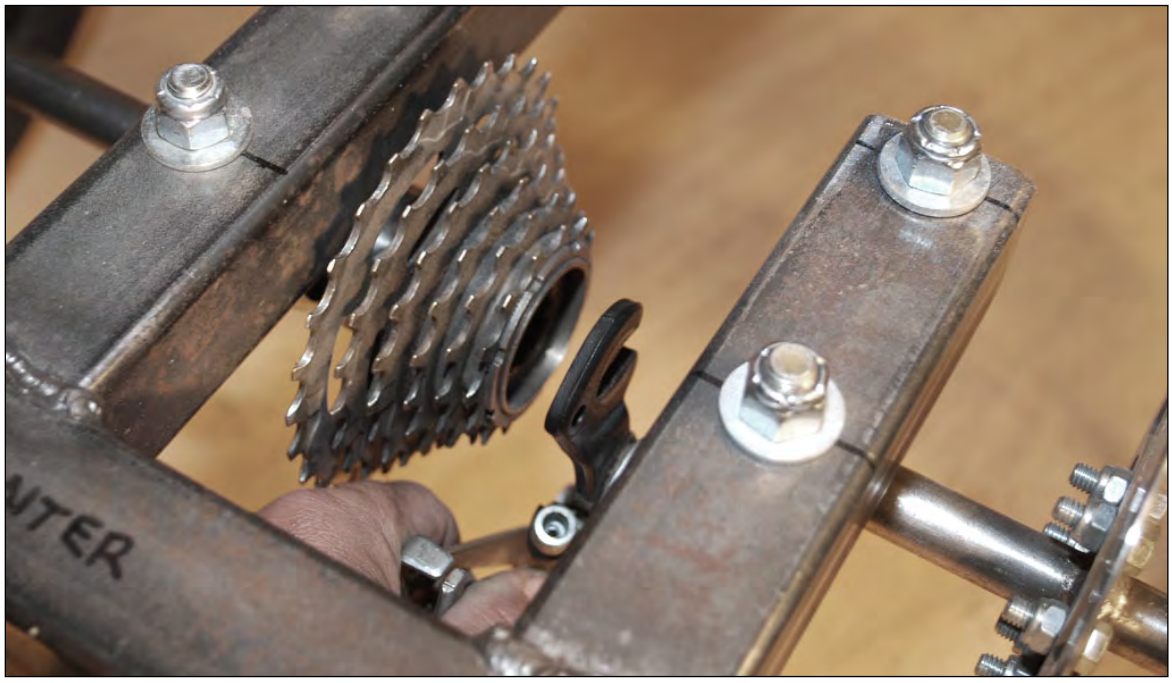

Figure 140 – Setting up the rear derailleur

There is no rear dropout or threaded axle to mount your rear derailleur, so you will need to "hack" something together to do this. A rear derailleur should be in a position so that the slotted area is about half an inch away from the center of the smallest chain ring as shown in Figure 140. This position will allow you to reach the full range of gears and allow the derailleur to function normally. There are many ways to achieve this goal, but I find that cutting and modifying the derailleur mounting hardware is the easiest method.

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REAR DERAILLEUR

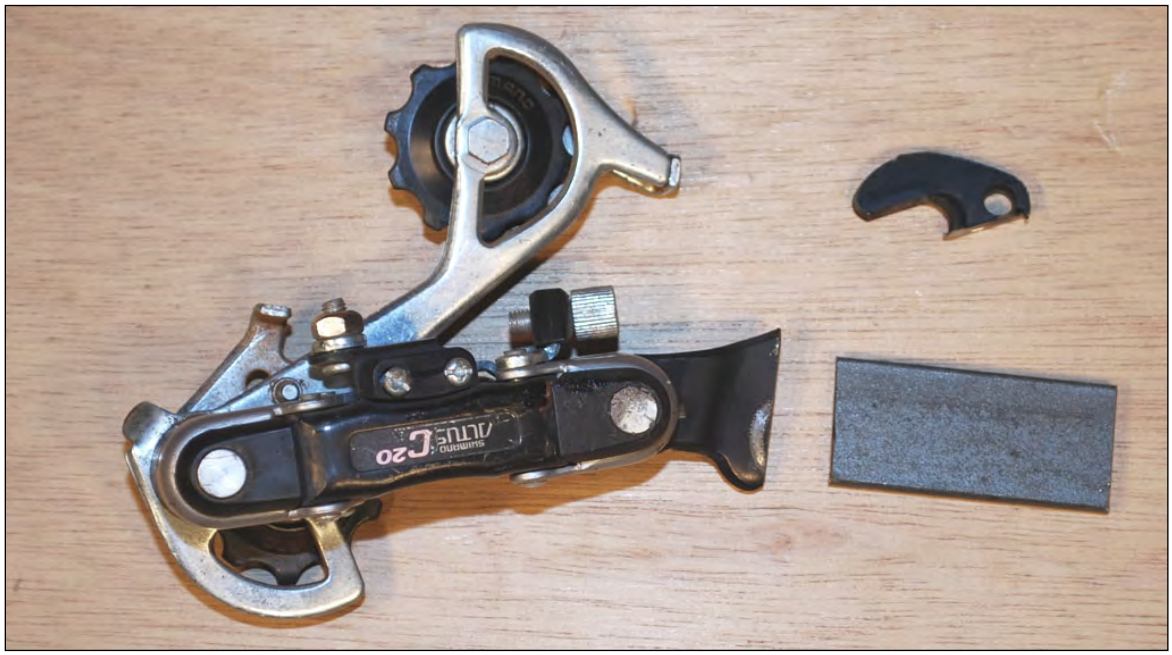

Figure 141 – Modifying a rear derailleur body

To modify the rear derailleur body to fit on an arm mounted to the frame tubing, hack off the slotted area and find of a bit of 1/8 or thicker flat bar to weld onto it to create an extension. Figure 141 shows the small 2.5 inch long piece of flat bar I used for this simple modification. Of course, the derailleur needs to be made of steel if this is to work properly.

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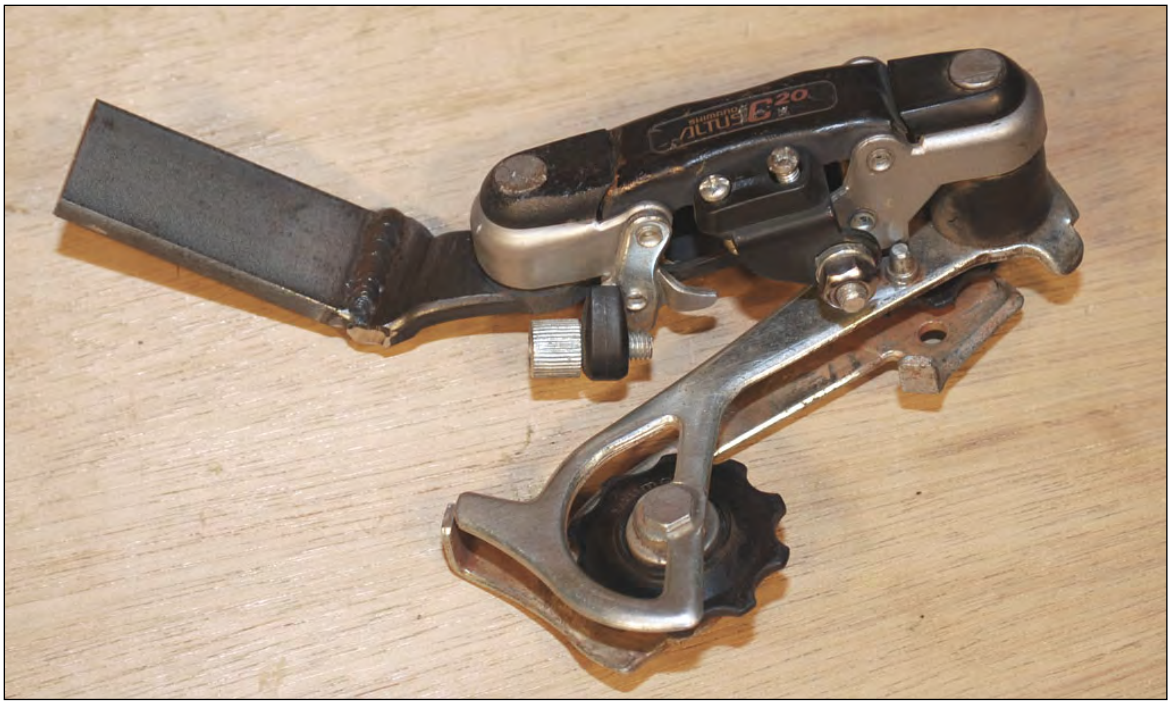

Figure 142 – Welding the derailleur arm

The new derailleur mounting arm is welded to the cut area as shown in Figure 142 at a slight angle so that it can connect with the nearest frame tube. Your derailleur may differ, so use whatever method and materials you can find to position the old axle slot at the center of the new trike axle.

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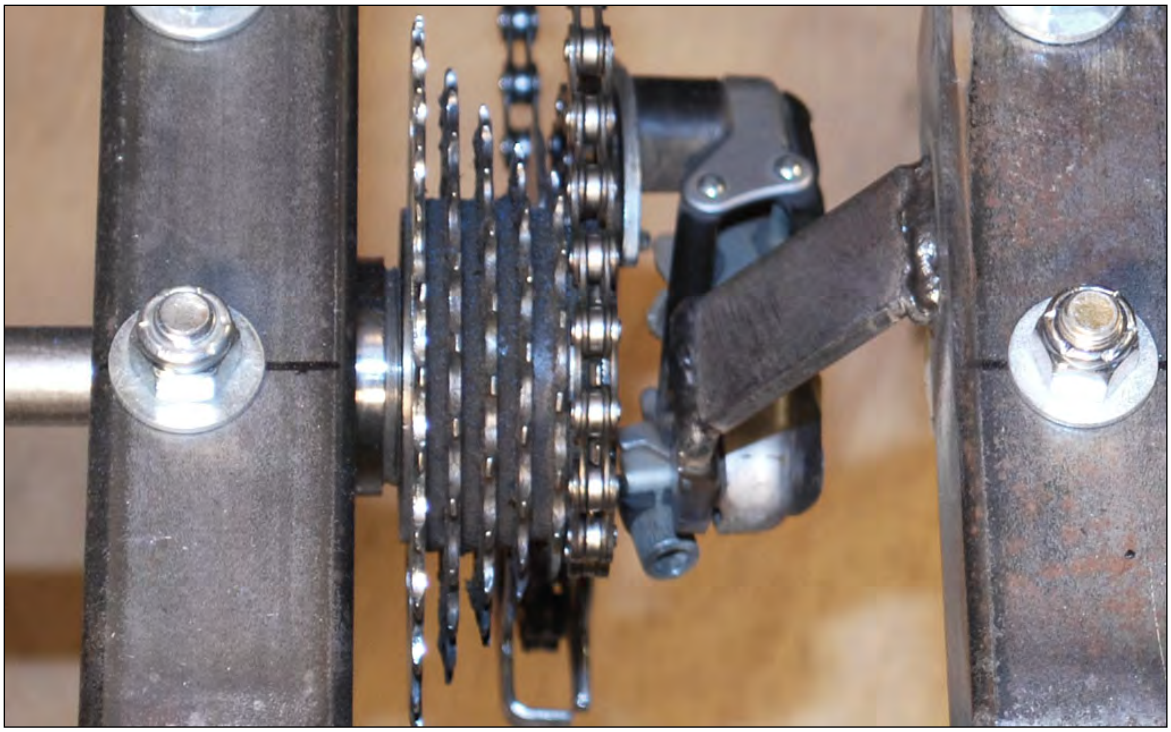

Figure 143 – Installing the modified derailleur

The modified rear derailleur arm is shown welded to the frame tubing in Figure 143. Now the derailleur is sitting in a position next to the freehub cluster exactly the way it was intended. If you need to see an example of proper rear derailleur positioning, take a look at a regular upright bicycle.

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CHAIN

Figure 144 – Making up a new long chain

The TimberWolf is so reclined that you will need almost twice the length of bicycle chain that you would normally require on an upright bicycle. Shown in Figure 144 is a wad of chain consisting of two new lengths of standard derailleur bicycle chain and an inexpensive tool that makes joining chains so much easier than the smack it with a hammer and punch system. Two chains joined together may be a little too long, but it's a good start, so go ahead and join them into one long single chain. Look out for those brain teasing loops!

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Figure 145 – Getting the optimal chain length

It may take a bit of fooling around to get that optimal chain length for a full range of gears, but a good start is to place the chain on the largest front chain ring and the middle rear chain ring so that it looks like what is shown in Figure 145. This is the most used gear selection, and the two small rear derailleur wheels should be almost in a vertical line. The sag in the return chain (lower side of the chain) will be picked up by a chain tube that will be shown later in the build.

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STEERING SYSTEM

Figure 146 – Cutting a head tube down to 3 inches

The TimberWolf features under seat steering for maximum comfort and makes it very easy to climb in and out. This steering system links a set of handlebars mounted under the pilot's seat to the front forks through a set of control arms and a long control rod. The steering system feels completely natural and places the pilot's hands in a relaxed and comfortable position for maximal control. To create the under seat steering system, common bicycle components will be used, which will allow the use of standard handlebars, brake levers and shifting levers.

You will need a head tube, a fork stem and a steel gooseneck to create the under seat steering system for the TimberWolf. The head tube only needs to be 4 inches tall, so you will have to measure and cut your head tube to this length as shown in Figure 146. Grind the 4 inch tall section clean using your sanding disc.

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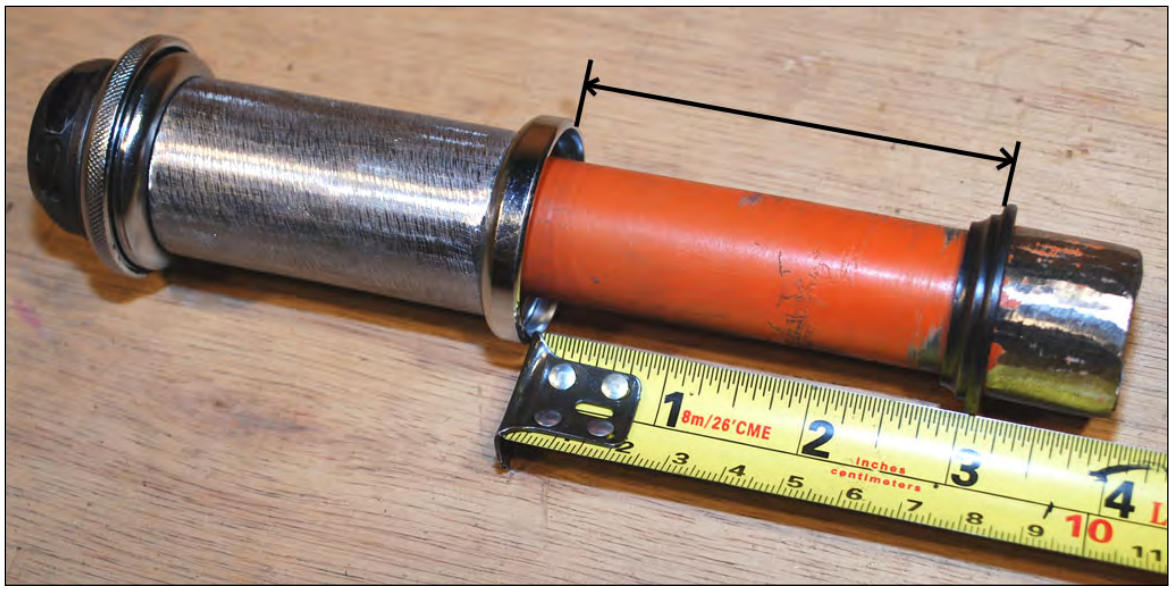

Figure 147 – Measuring the fork stem for cutting

You will not require the fork legs, so cut them away at the crown area and then grind the surface clean as shown in Figure 147. You will also need to shorten the fork stem once the head tube has been cut down to the required 4 inch height. To determine how much of the fork stem needs to be removed, install the all of the top hardware including the bearing and then measure the distance from the bottom of the lower cup to the top of the fork stem bearing race as shown in Figure 147.

Figure 148 – Marking the fork stem for cutting

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My fork stem needed to be cut down by 3 and 1/8 inches as determined by the step shown in Figure 147, so I marked the section to be cut. The fork stem needs to be shortened in the center so you are not trying to weld over either the threaded section or right at the bearing race. If you do not have an inexpensive pipe cutting tool, wrap some tape around the line to be cut as this will help you cut around the area in a more precise manner.

Figure 149 – Cutting the fork stem using a tube cutter

The inexpensive tubing cutter shown in Figure 149 is an extremely useful tool as it makes a perfect cut with minimal effort. It is important to make an accurate cut on the end of the round tubing because it will need to be fit back together for welding.

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Figure 150 – Setting up the fork stem halves for rejoining

To ensure that the two fork stem halves are rejoined in an accurate manner, place them inside a piece of angle iron and into a vice as shown in Figure 150. You can then make several tack welds to secure the alignment and then release the part for further welding.

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Figure 151 – Run a bead of weld on the underside of the fork stem

You can also cut some of the fork stem area down so that the crown is only half an inch long, but you will need to run a bead of weld around the underside as shown in Figure 151 because the crown area is actually made up of two tubes that are press fit into each other. If you do not intend to shorten the crown area, then this extra welding can be omitted.

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Figure 152 – The completed steering assembly after being shortened

The new miniature head tube and fork stem assembly is shown in Figure 152 after being shortened and reassembled. Ensure that all of the bearing hardware fits together properly so that the stem can spin freely once all of the hardware is installed and tightened.

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STEERING INSTALLATION

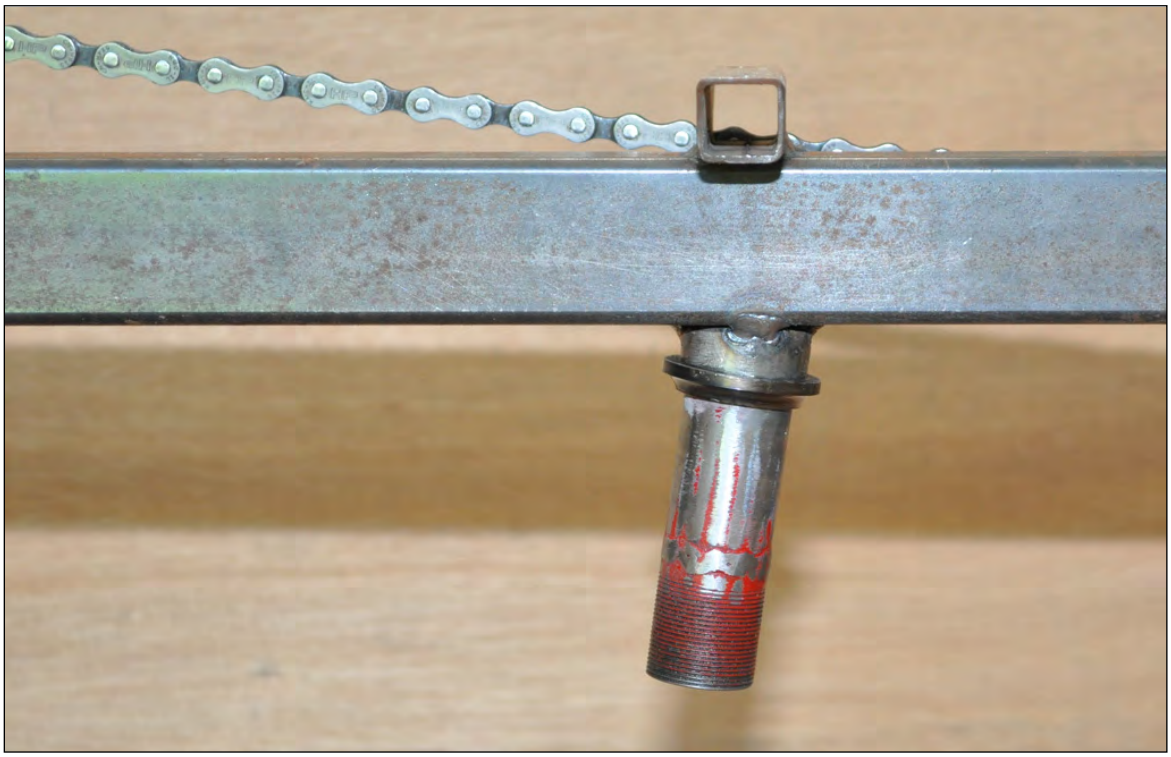

Figure 153 – Installing the pilot's fork stem under the seat

The pilot's steering system lives directly under the seat on the opposite side of the seat riser tube as shown in Figure 153. You will notice that the stem has been installed at a slight angle, leaning approximately 5 to 10 degrees towards the front of the trike, which in Figure 153 would be to the left of the photo. This slight angle helps align the steering control arms between the front forks and pilot's steering system. For now, tack weld the pilot's fork stem under the seat riser tube at the slight angle shown in Figure 153.

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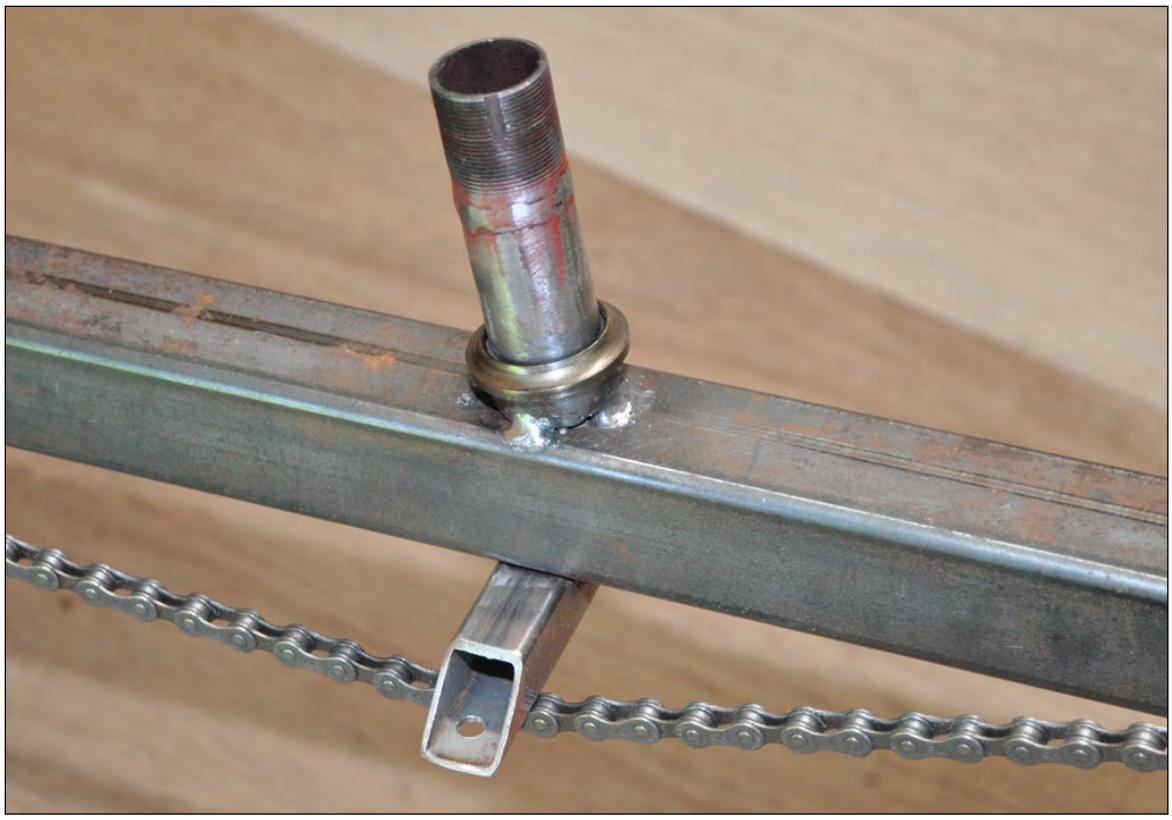

Figure 154 – Tack welding the pilot's fork stem under the seat

Make sure that the pilot's fork stem is aligned at 90 degrees to the frame as viewed from either end and then set on a slight angle pointing towards the front of the trike. Set four decent tack welds around the fork stem as shown in Figure 154 to lock it in place. Tap off the bearing race when welding so that you do not accidentally damage it during the welding process.

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HANDLEBARS

Figure 155 – The handlebar clamp is welded to the pilot's head tube

To allow for the installation of standard or modified bicycle handlebars, a steel gooseneck is cut up for the clamp, which is shown welded to the pilot's head tube in Figure 155. This clamp is placed in the center of the head tube and needs to be aligned so that the handlebars are parallel to the ground. Figure 156 shows how a straight handlebar can be used as a reference when setting up the clamp to be welded to the head tube.

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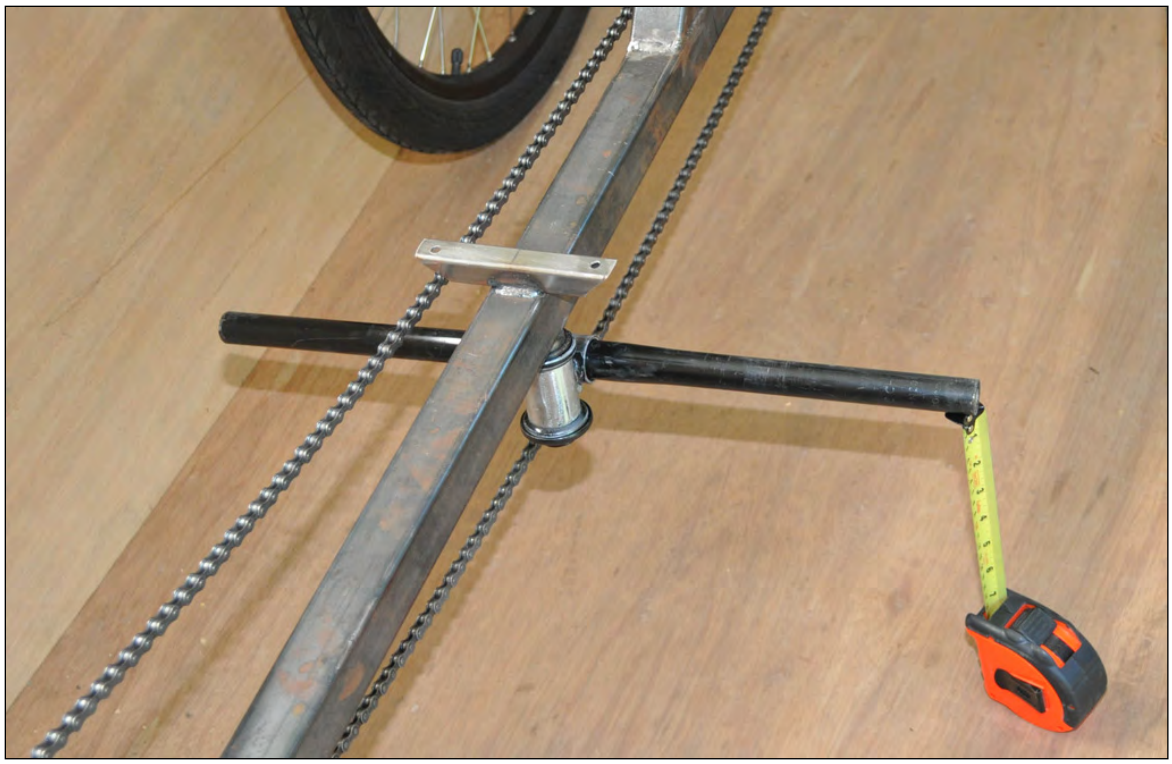

Figure 156 – Setting up the angle of the handlebar clamp

As shown in Figure 156, a set of handlebars or even a straight tube can be placed in the handlebar clamp once it has been tack welded to the head tube so adjustments can be made. The distance from each end of the handlebar to the ground should be the same at both ends. This will ensure that your handlebars are not tilted to one side or the other.

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Figure 157 – Some possible handlebars for modification

Handlebars are one of those things that will vary from person to person, so you will need to experiment a little to find the shape and size of handlebar that will fit your style. You won't likely find a standard handlebar that will be a perfect fit for this trike, so you will need to cut and modify one to suit your needs. The huge "ape hanger" handlebar shown in the right side of Figure 157 almost worked as is, but it hit the bottom of the seat while turning, so modification would be necessary. The other handlebars shown in Figure 157 are some of the ones I considered hacking up to extend the larger ones.

To decide how your handlebars will be shaped, sit on your seat with your feet on the pedals and place your hands in a grip position beside you where they feel most comfortable. I have seen production trikes that force the rider into a rigid long arm reach, but this is the last thing you want, so don't "cheat" and just drop on a straight handlebar or you will not end up with a very comfortable ride, especially on a long journey. Place your hands where you feel that they are most relaxed and then design your handlebars to meet you, not the other way around.

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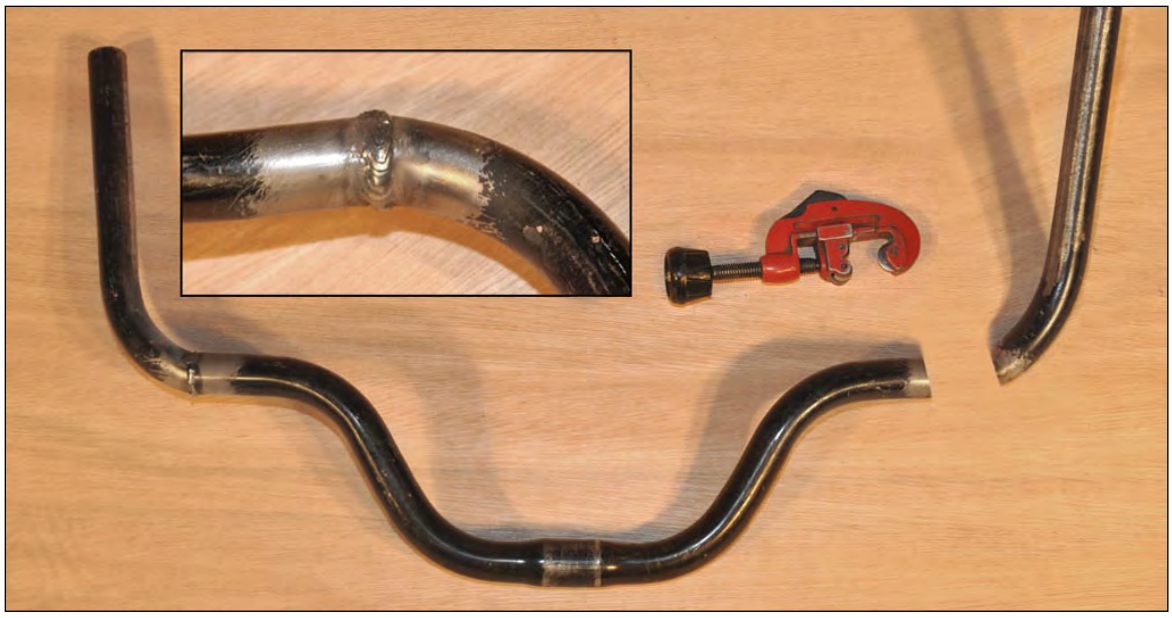

Figure 158 – Cutting and joining the handlebars for optimal fit

With a tube cutter and a welder, you can create any size and shape of handlebar possible, so once you have found your optimal grip position, work your way up by starting with a standard mountain bike handlebar like the one being used in Figure 158. You can add any similar size and thickness tubing into the mix as long as the center part that connects to the stem is left intact and as long as the handle grip ends are also standard handlebar tubing. I simply cut up two sets of handlebars and joined them as shown in Figure 158, making a system that felt comfortable and did not hit the seat when turning. Again, you will definitely need to experiment here.

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Figure 159 – The completed trike compatible handlebars

When welding handlebar tubing back together, ensure that your welds are done properly and only grind as much as you need in order to get the shifting hardware over the area. A little hill is always better than a valley when you are cleaning up welds. Figure 159 shows the handlebars I made that placed my hands just to the side at the slight wrist angle that seemed most natural.

Figure 160 – The completed custom handlebars installed

The completed trike ready handlebars are shown installed and set to what I found to be the most natural position (Figure 160). The grip area is angled slightly outwards and slightly forward as this is the position my wrists were in as I dropped my hands to the side to see where they felt most relaxed. A handlebar exactly like this would certainly not be available at bike shops.

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Figure 161 – The completed custom handlebars installed

When you are designing your perfect handlebars, take into consideration the chain and seat so that you do not end up with interference. The rotation of the handlebars shown in Figure 161 is more than you would ever need, but there is no chain or seat interference until the furthest possible rotation.

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CHAIN GUIDES

Figure 162 – The drive chain must find its way under the seat

With the handlebars installed, you can now work out the placement of the drive chain idler pulley and the return chain guide tube. The top of the chain is called the "drive side" of the chain because it carries all of the tension from the cranks back to the rear drive sprocket. The lower part of the chain is called the "return chain" because it is always slack and never has any tension at all. For these reasons, the drive chain needs to be bent under the seat using a strong ball bearing idler pulley and the return chain can be simply picked up by a rubber tube.

Pull down on the drive side of the chain as shown in Figure 162 until it finds its way under the seat and over the handlebars with no interference. Probably the best place for the chain to bend will be just ahead the seat corner as shown in Figure 162.

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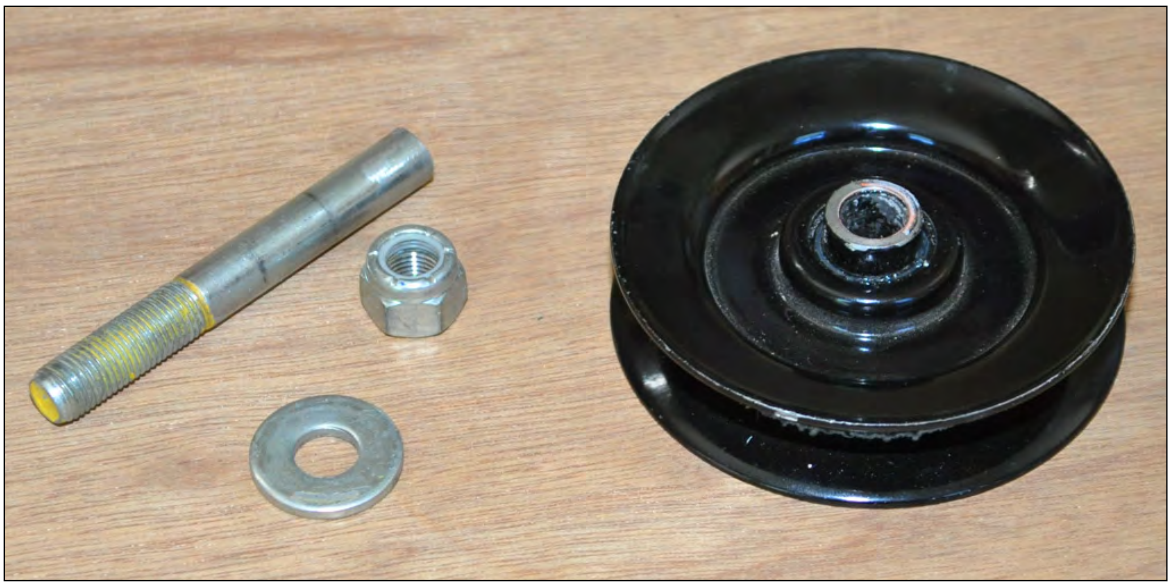

Figure 163 – Choosing a drive chain idler pulley

The best option for a guide pulley is a 2.75” to 3.5” diameter belt pulley made for a ½ inch V-belt as shown in Figure 163. This pulley will come with a decent bearing in the center and will allow the chain to sit nicely in the groove, making no sound whatsoever as you pedal.

Nylon or steel will work fine, but you should definitely avoid using any guide pulley with a diameter less than 2.75 inches, and don’t even try to use a rubber skate blade or skateboard wheel for this as they will not last very long and are made of material that is much too soft for the purpose. These half inch v-belt idler pulleys can be purchased at most hardware stores or any shop that services lawn and garden equipment. You will also need a bolt that fits the center of the pulley and sticks out about 2 inches on one side. Trim the head off the bolt as shown in Figure 173.

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Figure 164 – Finding the optimal position for the drive chain idler pulley

The goal is to bend the chain as little as possible and at the same time ensure that it will not strike the underside of the seat or the handlebar tubing as the handle bars are moved from side to side. Placing the idler pulley just under the seat near the back corner as shown in Figure 164 will probably be your best bet, but experiment to see how things work with your own handlebars.

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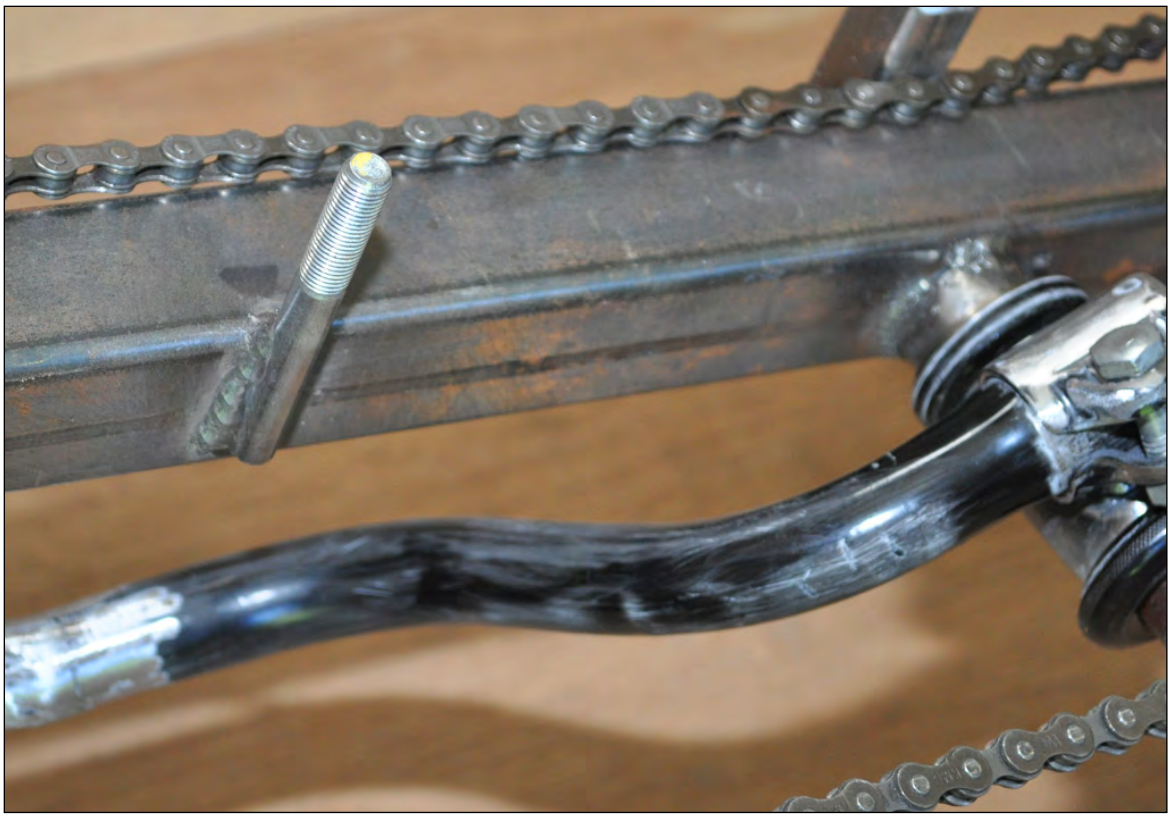

Figure 165 – Installing the idler pulley mounting bolt

The idler pulley mounting bolt will be welded to the frame as shown in Figure 165 so it can be positioned about ¾ inch away from the side of the frame with a spacer as shown in Figure 166. The idea is to have the pulley in a place that aligns the chain along the frame when it is placed on the largest crankset chain ring and on the middle rear freehub chainring. Installing the pulley about ¾ inch away from the side of the main boom tube will be good enough.

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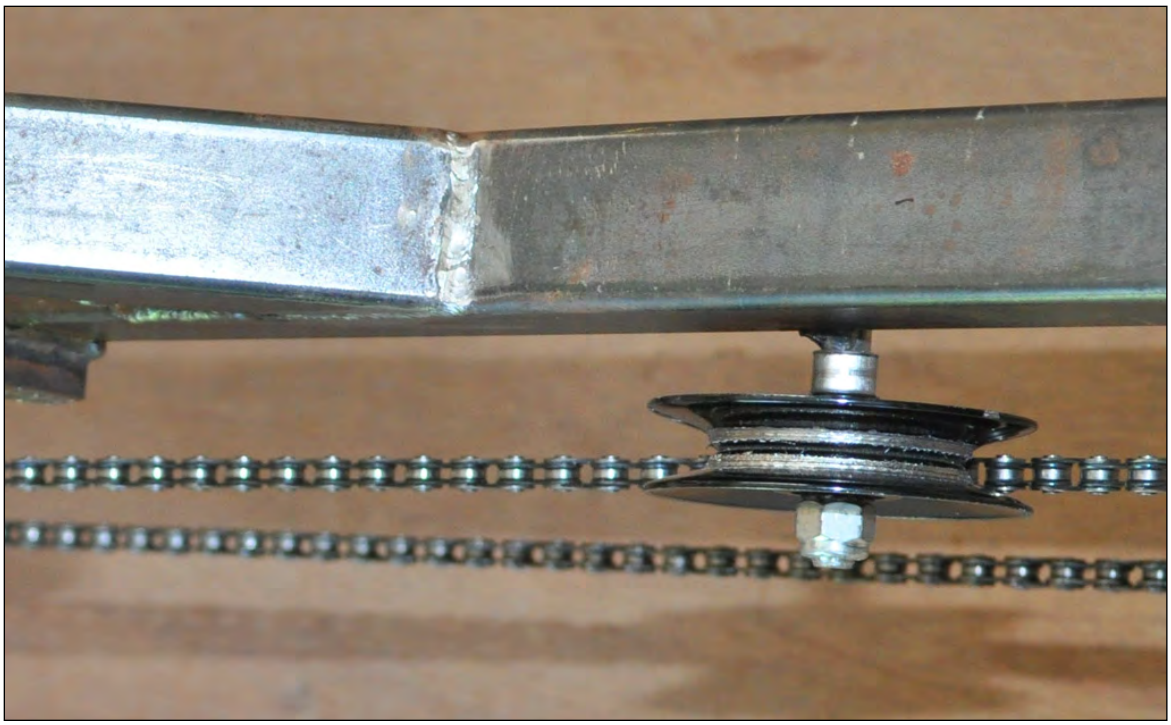

Figure 166 – The idler is placed ¾ inch away from the frame tubing

Figure 166 shows the ¾ inch of space between the idler pulley and the main boom tube, provided by the small bit of tubing slide over the bolt to create a spacer. Washers can also be used for this purpose.

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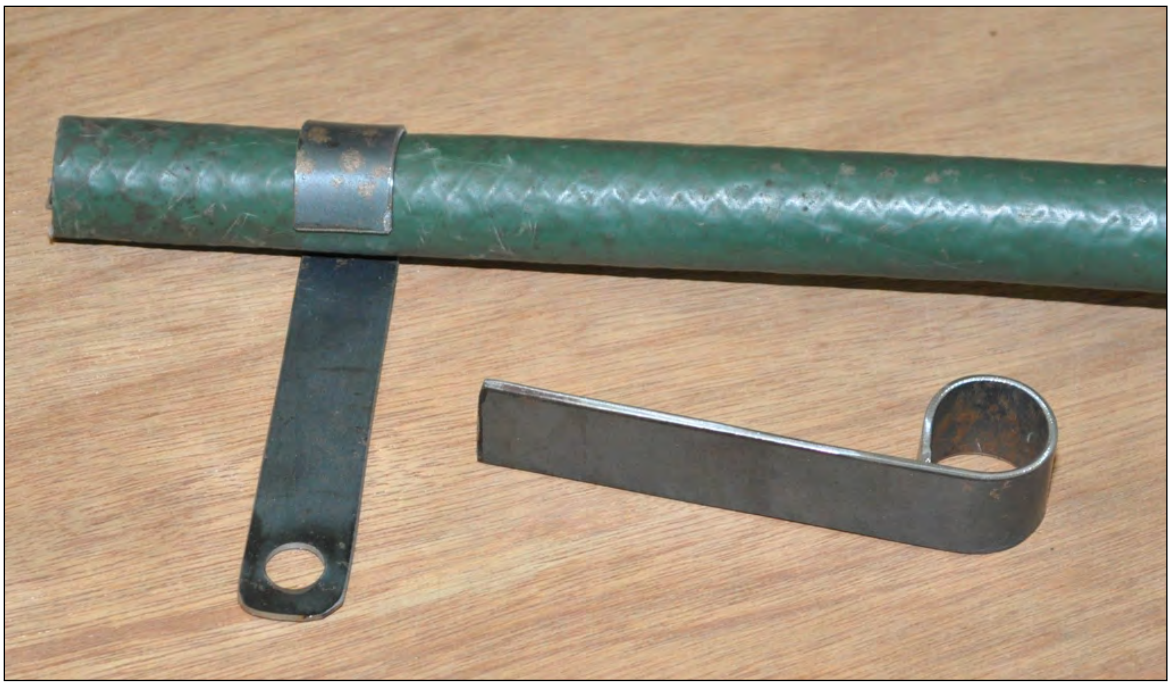

Figure 167 – The return chain guide is just a piece of garden hose

The return side of the chain is now left flopping in the breeze and certainly does not look very professional left like this, so a simply chain pickup system can be made from an 18 to 10 inch length of standard garden hose. Since the return chain is never under any tension, it will just slip through the hose without any friction, keeping it from bouncing around or collecting dirt as you bounce over rough terrain. 18 inches of garden hose and a pair of hooks made by bending some thin 1 inch strips of 16 gage sheet metal will do the trick. The simple hooks shown in Figure 167 are made be bending a loop at the end of a 7 inch long strip so they end up approximately 4 inches long. One is welded to the frame and the other will hang from the idler pulley mounting bolt.

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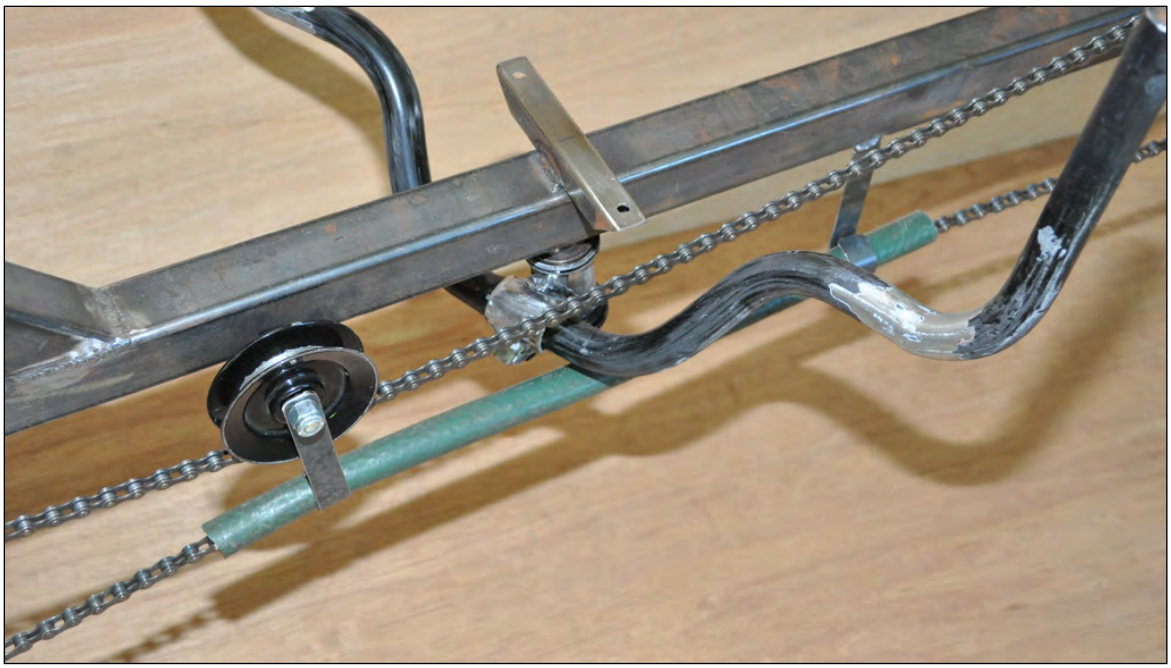

Figure 168 – The return chain idler tube installed on the frame

Figure 168 shows how the two hooks hold the return chain pickup tube just beneath the handle bars, allowing the slack return chain to be kept from bouncing around during rough riding. If the rubber hose happens to touch the handlebars slightly, it's not much of a concern since there is no tension in the chain.

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Figure 169 – A side view of the new chain line

Figure 169 shows the new chain line after installing both the drive chain idler pulley and the return chain pickup hose. The TimberWolf is now ready for the final steering components.

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STEERING LINKAGE

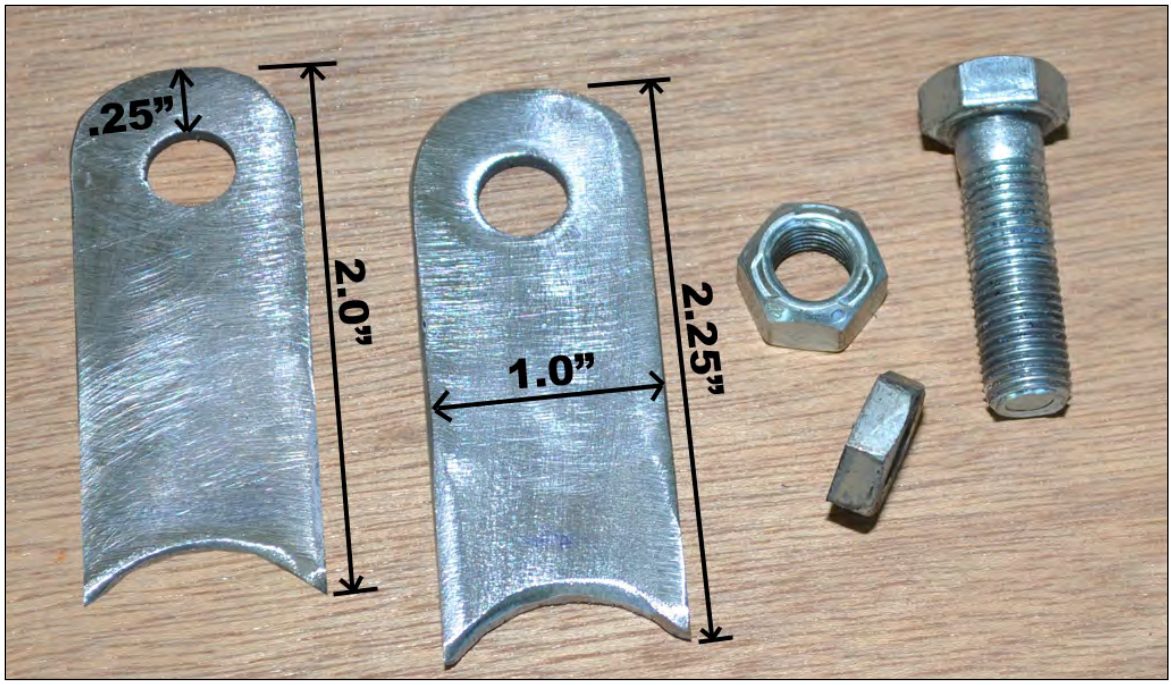

Figure 170 – The steering control arms

The pilot’s steering system connects to the front steering system through a pair of control arms, aspherical bearings (ball joints) and a control rod. The two control arms are shown in Figure 170 and are made from lengths of 1 inch wide, 1/8 or 3/16 inch thick flatbar. Notice how one control arm is slightly shorter than the other. The short control arm (2 inches) will be connected to the front forks while the longer control arm (2.25 inches) will be connected to the pilots head tube. This difference in length creates a small mechanical advantage in the steering system to allow for a more full range of steering.

The bolt holes in the control arms are made to whatever size bolt holes your ball joints require, and the hole is placed on the control arm so that there is about a quarter inch of space from the end of the part. The rounded bottom of each control arm is made to conform to the head tube shell and fork leg where they will be attached.

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Figure 171 – Installing the pilot's side control arm

The pilot's side control arm (the longer one) is welded to the left side of the pilot's head tube shell as shown in Figure 171. If you look ahead, you can see how the control rod is placed on the left side of the trike to sneak along the frame between the boom and the left crank arm. The control arm is welded so that it is at 90 degrees to the frame tubing as shown in Figure 171. The control rod will be placed over the handlebar tubing, so place the control arm up high enough to account for this. It is a good idea to only tack weld all of the steering parts together at first and then complete the welding once you have the steering working the way you like.

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Figure 172 – Installing the front fork control arm

The front fork control arm (the shorter one) will be installed on the left side of the front forks at 90 degrees as shown in Figure 172. The face of the control arm should angle slightly as if drawing a line back to the pilot's control arm so that the ball joints and control rod can sit flat on both control arms. Place the front fork control arm up near the fork crown, and remove the bearing race when welding to avoid damage.

Figure 173 – Ball joints, and a control rod link the steering system

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The steering control arms are linked together by a control rod with two ball joints (aspherical bearings) at each end. The steering on the TimberWolf feels no different than that of a regular bicycle since the operation of the linkage is almost transparent to the pilot. A control rod made from a length of hollow ½ inch tubing will have a pair of ball joints mounted at each end so that the two front control arms are linked together. Because the ball joints can be screwed into the rod, slight steering alignment fine tuning is possible as well.

The ball joints or a spherical bearings are rated by their bolt hole size. The ones I always use are made for a 3/8 bolt, and include a bolt body so that they can screw into the nut welded at the end of the rod. It's easy to calculate how long to make the steering control rod by setting the front wheel and handlebars in the straight ahead position and measuring the distance between the hole centers on both control arms.

This hole-to-hole distance between control arms should match the hole-to-hole distance on the control rods ball joints once you assemble the control rod system.

Figure 174 – The ball joint threads into the nut welded to the end of the rod

To set up the control rod so that it offers some fine tuning to make slight steering alignments, weld a nut to the end of the rod so that the ball joint body bolt can screw into the rod as shown in Figure 174. A second nut can then lock the position of the bolt so it will no longer turn. When welding the nut to the end of the rod, screw in a spare bolt to help center the nut and protect the threads from welding spatter. Do not have

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the ball joint in the nut when welding as the bearing may be damaged from the heat. Use a spare bolt of the same size.

Figure 175 – The control rod will live between the frame and the left crank arm

Figure 175 demonstrates how the control rod will sit between the left side of the frame and the left crank arm, but not hit either side during handlebar rotation. The control rod may come very close to the crank arm depending on the style of the crank arm, but should not be allowed to rub on the arm as it rotates.

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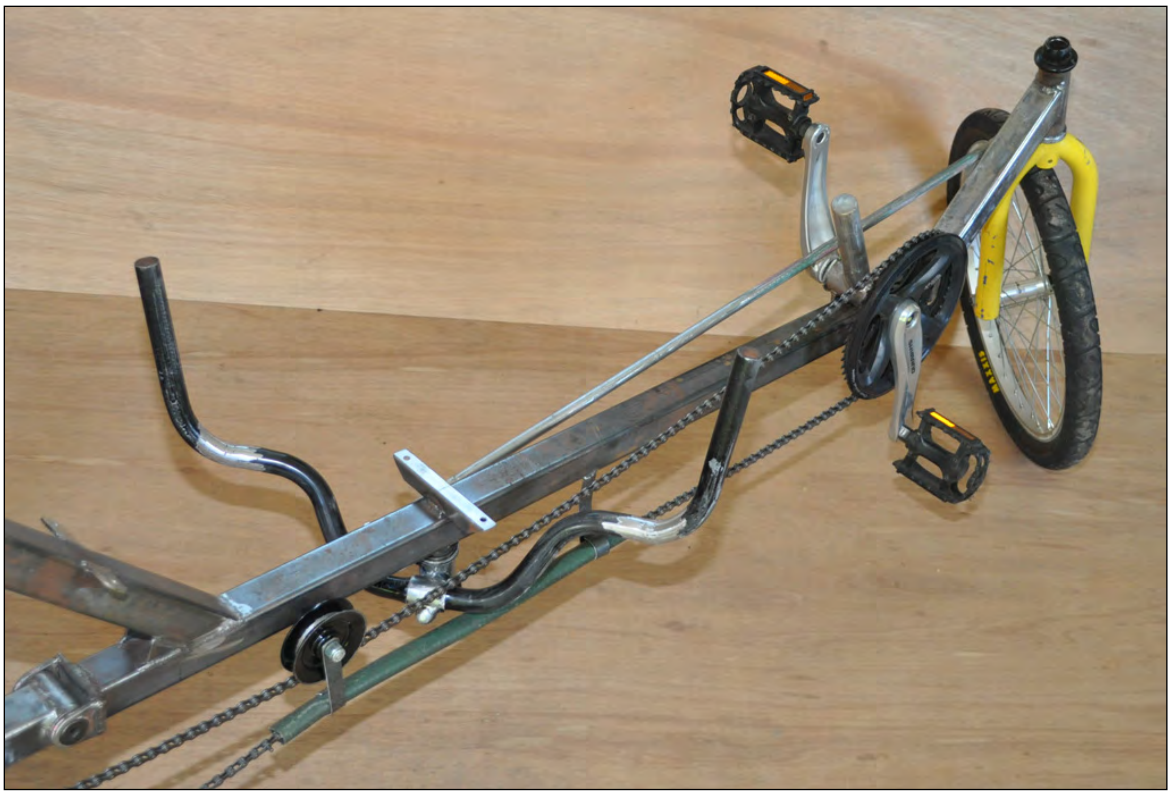

Figure 176 – Testing the range of steering rotation

Once you have installed the steering linkage, turn the handlebars back and forth to test the range of steering available. Forty-five degrees is plenty of rotation for the front wheel, and under normal riding conditions you will use a lot less than what is available her before lockout. You may also find that the steering can move to a sharper angle in the left direction because the control rod strikes the side of the frame during a sharp right hand turn. This will be fine.

Another thing to note is that you may require a little space between the top of the control arms and the ball joint body as there may be some rubbing as you turn. I have found this necessary when using the flat faced ball joints as shown in Figure 174, but this is an easy problem to solve. To make spacers that will lift the ball joints slightly, grind down a nut to about half of its thickness and then place it between the ball joint and the control arm. This creates enough space so that the body will no longer rub against the control arm in tight turns.

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Figure 177 – The TimberWolf with a fully functional steering and transmission system

Your TimberWolf is now functional enough to ride, although you will be stuck with a single speed and have no ability to slow down! If you have a nice quiet place to test ride your trike, set the derailleur adjustment pins to some middle gear and go see how the steering handles. If you would rather finish the entire project before setting out on a test run, then all that is left to do are brakes, cables and paint.

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BRAKE STUDS

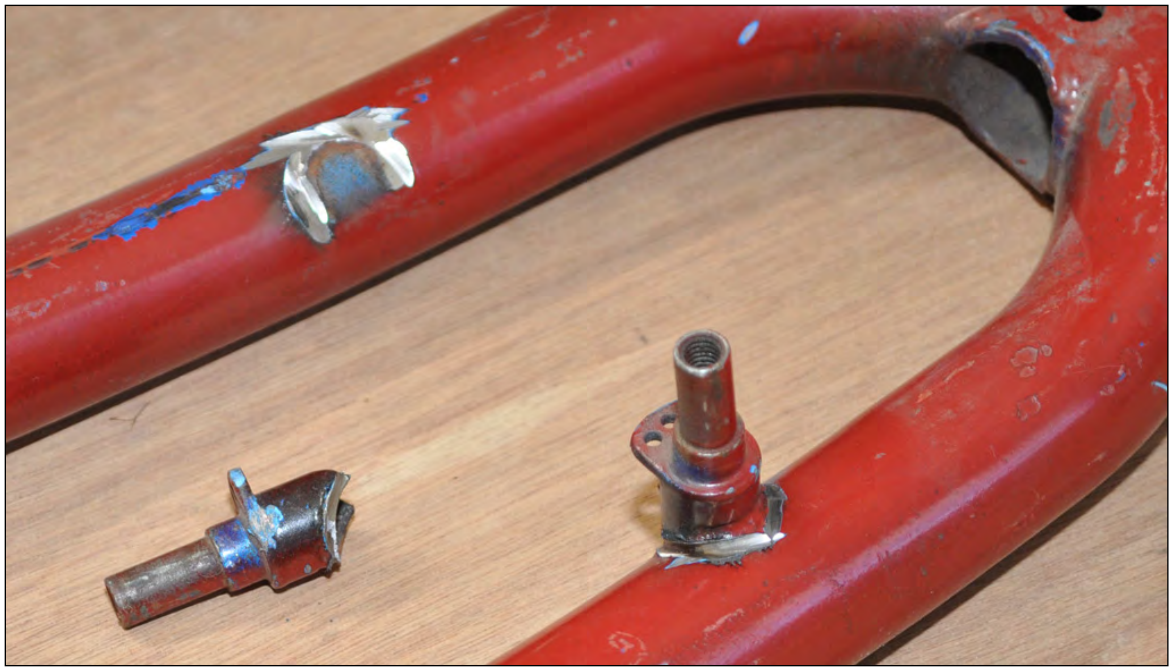

Figure 178 – Removing brake studs for transplant to another fork set

The TimberWolf has a rear disc brake and a front pad brake, which is plenty of stopping power. If your chosen front forks already have brake studs installed then you are all set, but often 20 inch forks do not have brake studs as the small bike they came from might have had a single rear coaster brake or a bolt on side pull brake. For optimal front braking power, cantilevered brakes are best, and you can easily transfer the brake studs from one set of forks to another.

To remove brake studs, use a hacksaw or zip disc to carefully cut along the weld until the part is freed as shown in Figure 178. There will be some surface damage to the fork legs, but if you plan to reuse these forks, a little welding and grinding can easily fix them later.

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Figure 179 – Install the brake studs into the brake levers

To align the brake studs to the new set of forks, install them as shown in Figure 179, just as they were when the original brakes were installed and functioning. You will be using the brake pads against the rim to calculate the placement of the brake studs on your 20 inch forks. Do not load the spring into the hole though, or you will not be able to turn the stud.

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Figure 180 – Aligning the brake studs onto the 20 inch forks

Using the brake pads as an alignment guide, place the stud on the fork leg as shown in Figure 180 so that the pad strikes the wheel in the correct position. The brake stud will be standing off of the fork leg at 90 degrees and pointing directly forward when aligned properly.

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Figure 181 – Marking the optimal placement for the brake studs

Mark the placement of both brake studs as shown in Figure 181and then verify that they are both at an equal distance down the fork leg. The marks are made once the paint has been removed, but for photo clarity, I have drawn them over the paint.

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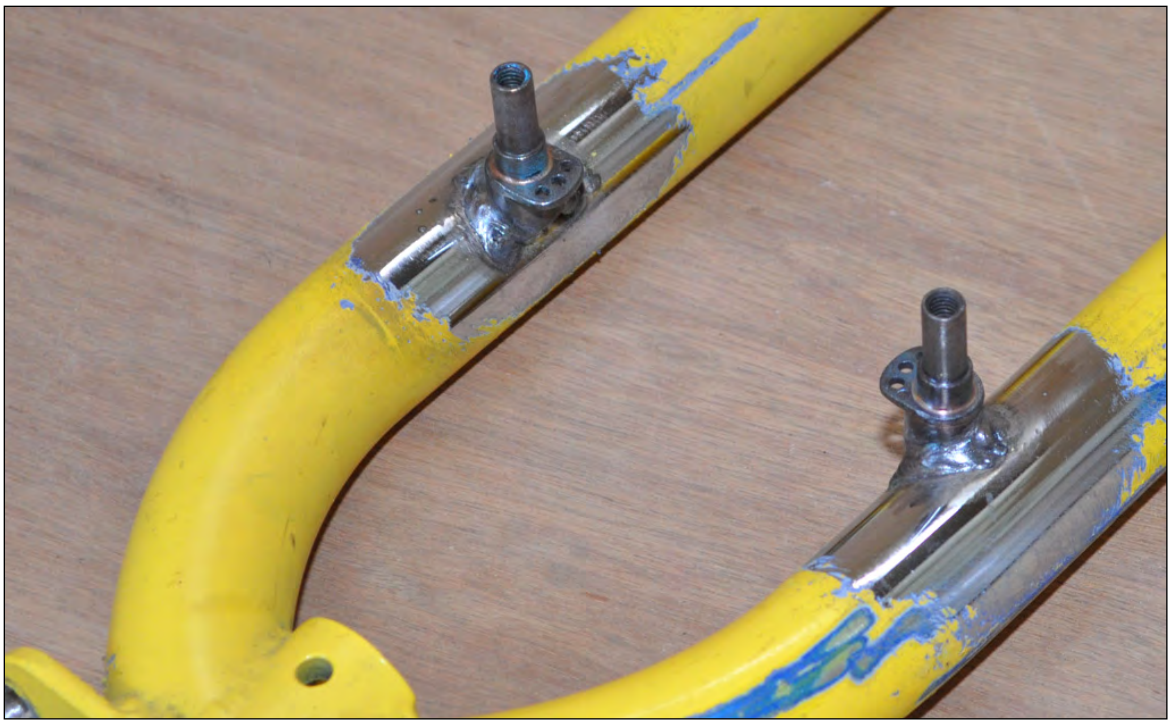

Figure 182 – Welding the brake studs to the fork legs

Weld the brake studs to the fork legs in the place you have marked as shown in Figure 182, making sure to weld all the way around the sides just as they were on the original fork legs. If you have made a slight alignment error, this can be corrected when you align the brake pads on the rim surface.

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DISC BRAKE MOUNT

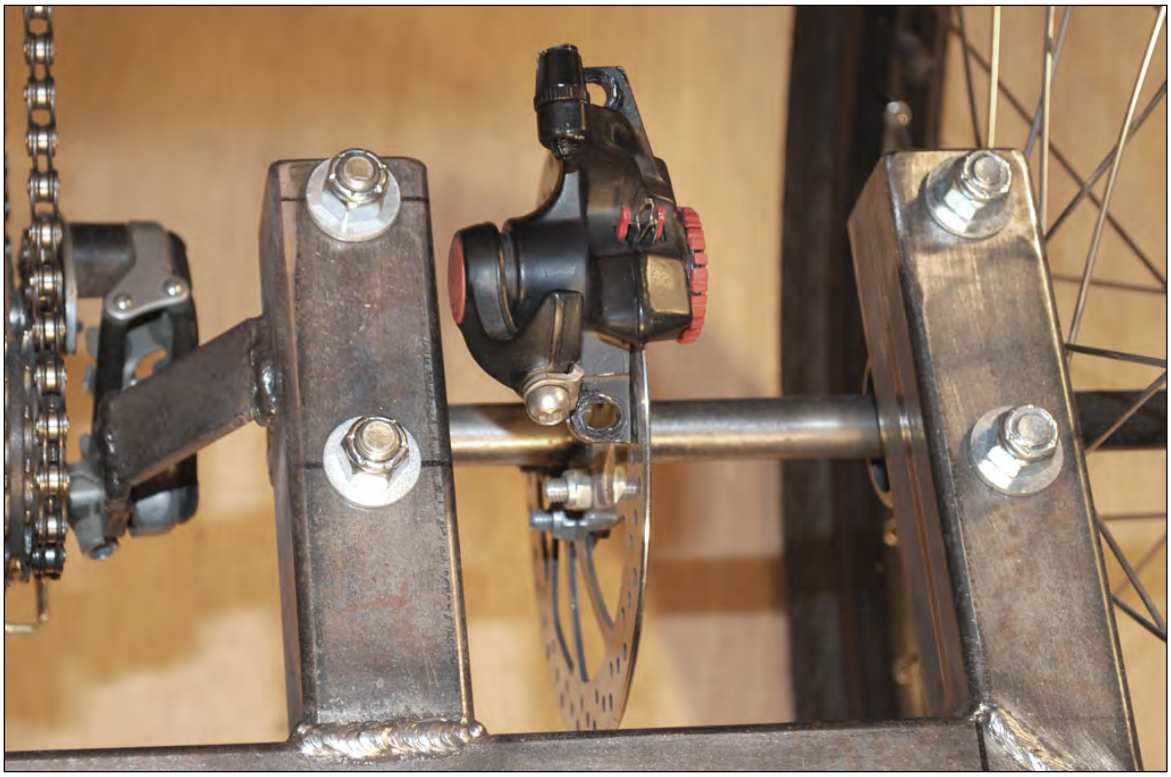

Figure 183 – Determining the best placement for the rear disc brake

Cable activated disc brakes are affordable and work great for delta trikes. There are many styles and styles of disc brake hardware available, but all of them can be adapted to your frame with a few bits of flatbar or angle iron. The goal is to get the calipers over the disc so they get a full bite without rubbing and so that the cable will be exiting the hardware towards the front of the bike, preventing a huge cable loop.

Many brakes are “self centering”, so you can just drop them on the rotor and then crank the dial until they take a firm grip to stay in place. From there you can figure out what type of hardware will be needed in order to fasten them to the frame in the optimal position. Figure 183 shows my disc brake hardware tightened to the disc in a position that seems easy to mount as well as placing the cable entry towards the front of the trike.

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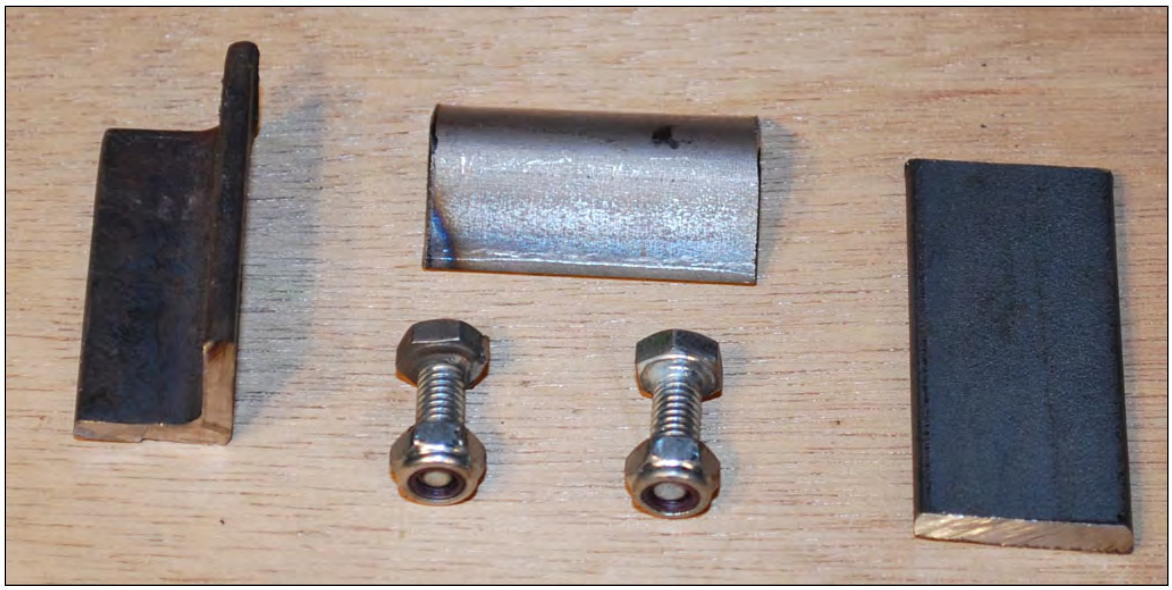

Figure 184 – Some parts used to fasten the rear disc brake

When working out the small bits that will be needed to hold the disc brake in the appropriate position, only use flatbar or angle iron with a 3/32 or better thickness as there will be a lot of force on that brake during use. Figure 184 shows some of the small parts I plan to use to mount the brake. The mounting bolts are high grade and have locking nuts.

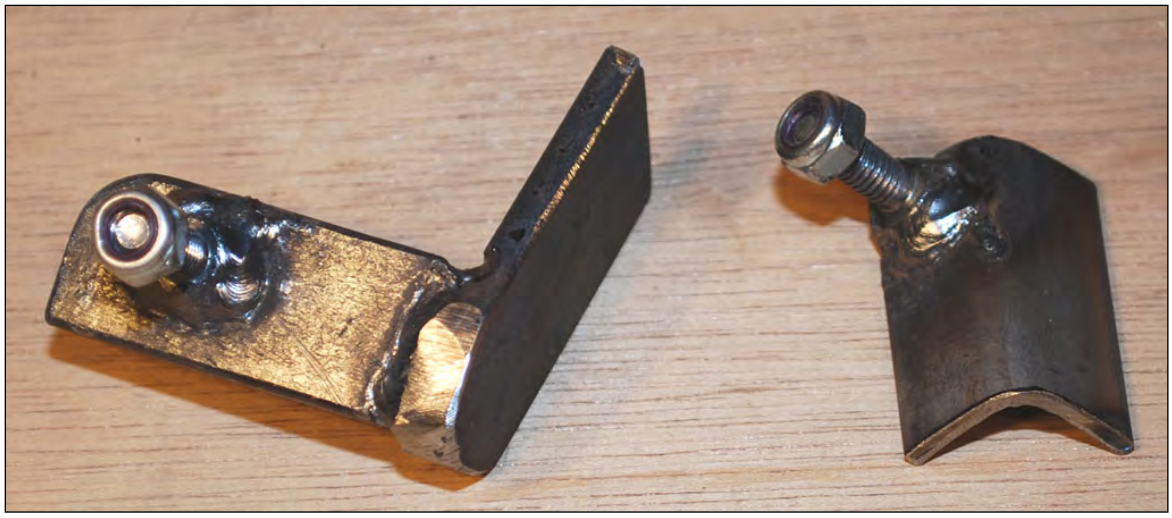

Figure 185 – My completed disc brake mounting hardware

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Designing the disc brake mounting hardware shown in Figure 185 is done by locking the brake in place and then working backwards, one step at a time. Disc brakes vary somewhat in design, so your hardware will probably look different than mine. The goal is to secure the brake hardware in the position you found most suitable, so start with the arms and then work towards the bolts. Some adjustment can be done later at the brake hardware itself.

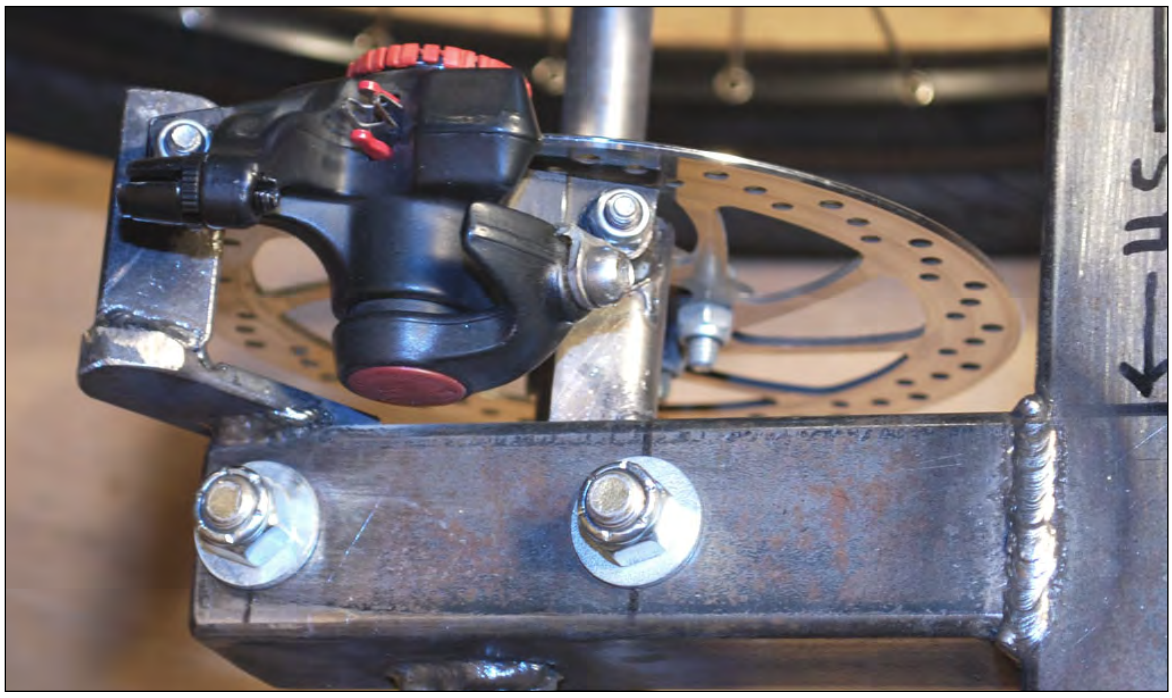

Figure 186 – Welding the brake hardware to the frame

The easiest way to align the disc brake hardware is by securing your mounting hardware to the brake, lock the brake onto the disc, and then solidly tack weld the hardware right in place. Cover or tape the brake hardware so the welding does not harm the plastic parts. Also, ensure that the pads have good grip in the disc, but don't place the inside of the slot so close that the top of the disc rubs on the brake body. If the disc brake does not have a self centering adjuster so it can lock, just tie wrap the lever in the "full brake" position. Only tack weld the parts with the brake installed and then remove it to complete the welding or you will damage the brake hardware from the heat.

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Figure 187 – A different style of disc brake and the mounting hardware

Figure 187 shows another style of disc brake that I have adapted for trike use. Note the different mounting hardware used for this style of disc brake.

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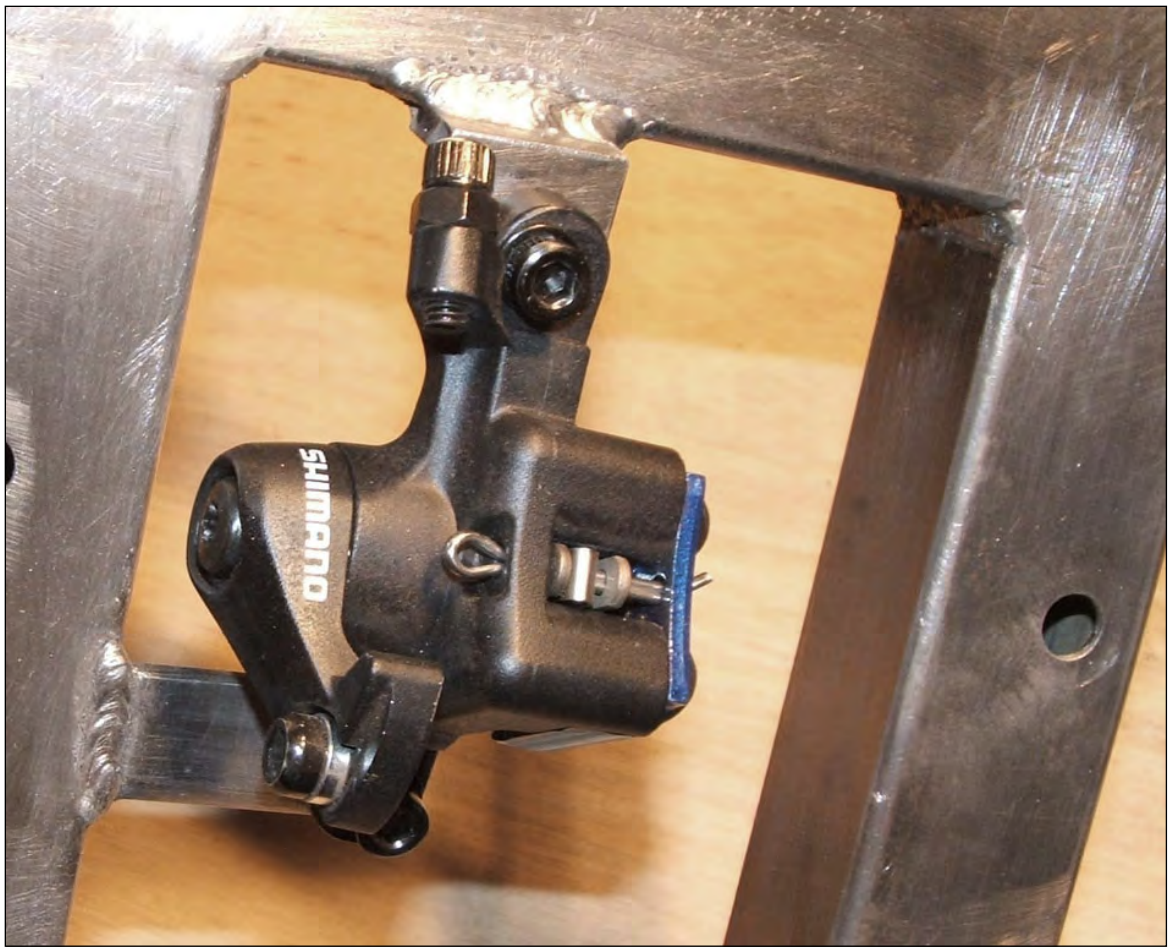

Figure 188 – The disc brake hardware welded to the rear of the frame

Remove the brake hardware to complete the welding, making sure to securely weld the joints that will be taking all of the braking forces. The disc brake hardware is shown installed after the parts have cooled in Figure 188.

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CARGO BOX

Figure 189 – Test fitting the optional rear cargo box

The TimberWolf is designed with some room behind the seat to add a small cargo box or even a battery pack for an electric assist kit. Your imagination is the limit from this point on, and as long as you can fit the box between the wheels, just about anything can be fit onto the trike. I found this lightweight plastic cooler that fit perfectly, and decided that this would become my cargo box, as well as the color scheme for my paint.

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Figure 190 – These tubes will become a cradle for the cargo box

To install the cargo box (cooler) onto the rear of the frame, a few ¾ inch square tubes will be cut and welded together to form a cradle that will allow the cooler to be bolted in. The cargo box should be affixed to the rear seat tube so that it gets to ride on the suspended part of the bike. Mounting the cargo box directly to the rear of the frame would mean that all bumps in the road will be transferred to the box, negating the effects of the suspension system.

Figure 191 – Making a frame around the cargo box

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The three square tubes are welded into a frame that will hold the cooler just under the handles. I will need a bolt through the sides of the cooler as well to secure it to the frame.

Figure 192 – Making a mounting system for the cargo box

To ensure that my six pack of water won't fly out of the cooler on rough terrain, I decided to fasten the cooler to the frame using a pair of bolts. The ends of the frame will be capped by the piece of angle iron shown cut and drilled in Figure 192. The end caps will also become mounting tabs for the bolts that will pass through the cooler body.

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Figure 193 – Welding mounting tabs to the open ends of the tubes

The mounting tabs are welded to the open ends of the tubing and then ground clean using a flap disc. Figure 193 shows the completed mounting system that will hold the cooler in place behind the seat.

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Figure 194 – The cargo box frame is welded to the rear seat tube

To keep the cargo box on the suspended portion of the frame, another small square tube is welded just behind the top of the rear seat tube to connect the cargo box mounting frame behind the seat. The two small trusses shown in Figure 194 give the assembly a little more side-to-side strength and keep the cargo frame aligned parallel to the ground. This configuration would be good for about 100 pounds, although I doubt I could pack that much into that small cooler!

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Figure 195 – The cargo box is now installed behind the seat

As shown in Figure 195, the cargo box is now on the suspended portion of the trike, so it will not suffer the shock from the road, so groceries or breakables would be safe. This simple mounting configuration would also make it easy to create other types of cargo boxes that could just bolt on from the sides.

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FINISHING TOUCHES

Figure 196 – Making a few mounting brackets for a set of lights

Now is the time to add all of the bells and whistles to your trike because after the paint is on, it will be a lot more work to make modifications. I found a few battery operated lights and made the appropriate mounting tabs from some scrap metal parts. The red lights shown in Figure 196 will mount to the rear of the frame and the white lights will mount to a ring that will lock over the front fork hardware.

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Figure 197 – Adding a set of battery operated headlights

The plate and ring shown in Figure 196 are welded together so that they form a mounting system for the two lights as shown in Figure 197, using the head tube hardware to hold them in place. These lights are not bright enough to light a road at night, but are definitely good enough to make you more visible to oncoming traffic.

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Figure 198 – Making a closed top fork cap

To close off the top fork hardware from the rain, a steel top fork nut can be made into a solid cap by welding a washer to the top and then filing in the hole. With a little careful welding and grinding, the completed part shown in Figure 198 looks like it was turned on a lathe.

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PAINTING

Figure 199 – The sanded and taped parts ready to be primed

Once you have completed all of the welding, take apart the entire trike and go over any rough spots with some emery cloth. It is not necessary to have the metal absolutely spotless for painting, but old paint should be sanded smooth and all grease must be cleaned from the bare metal. Tape up all bearing surfaces and other areas you do not want to have painted.

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Figure 200 – The TimberWolf frame is sent to the paint shop

I am often asked if I have my bikes professionally painted, which is funny considering my paint shop is what you see in Figure 200 - an old tree branch, a ladder, and a few cans of discount spray paint! A sprayed on paintjob is certainly not as scratch resistant as a professional auto paint job, but for a total cost of $20, it is not that bad and looks almost as good. Follow the directions on the primer and paint, and you will end up with a paint job that will look good and last for years.

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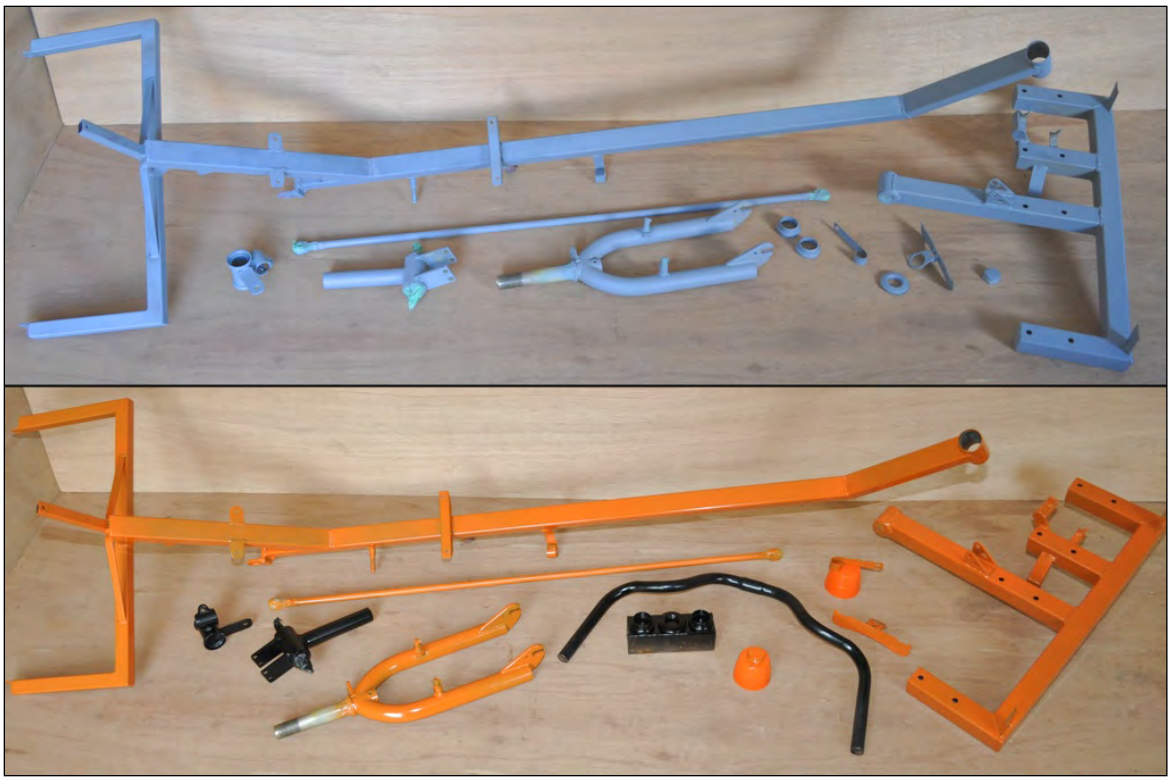

Figure 201 – The primed and then painted TimberWolf frame

Because the rear cargo box was already bright orange, I decided to match the color. The bright orange would make for a highly visible trike along the tree line where I was going to ride, and it was easy to find the exact same color in a spray can. Figure 201 shows the primed frame, which was set to cure for a day before applying the orange body paint and black trimming paint. All painting was done outdoors in the afternoon when the mosquitoes and black flies were not so bad. There's nothing worse than dead bugs in your nice paintjob!

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FINAL ASSEMBLY AND RIDE

Figure 202 – Assembling the bare bones trike

Once your paintjob has had a day or two to cure, assemble the basic trike components, giving the bearings a fresh coat of grease. Bicycle bearings such as those in the headset and crankset should be checked each year and re-greased if necessary. Standard axle grease form the hardware store is all you need for bicycle bearing parts. Figure 202 shows the bare bones TimberWolf assembled after greasing all of the ball bearing hardware.

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Figure 203 – The rear of the TimberWolf after paint and assembly

The rear of the trike is assembled, using nylock nuts on all of the axle bolts as well as the disc brake bolts. These nuts include a nylon plastic top that creates a nut that will not shake loose over time due to vibration. These are highly recommended on the disc brake and axle bolts. Remember not to crank the axle bolts on too tight or you may crush the frame tubing. Tighten them only enough to get a lock, and ensure you have 1 inch washers under the nut as well.

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Figure 204 – Installing the steering linkage

The ball joints are usually oil-impregnated, but it won't hurt to add alight brushing of grease on the moving part just to help keep them clean. The bolts that connect the ball joints to the control arms are also finished with nylock nuts just to be safe. If you are a perfectionist and want to avoid a ding in your paint job where the steering rod locks out against the frame, you can add a stick on pad or some protective tape on the strike area. Often, this is done on the right rear chain stay of an upright bicycle where the chain may strike and chip the paint. Figure 204 shows the steering linkage sitting on the freshly painted frame.

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Figure 205 – Setting up the position of the front derailleur

Most of the bicycle controls and components are very easy to set up, but the derailleurs may require a little more careful adjustment in order to set the minimum and maximum travel through the entire gear range. Both have a minimum and maximum adjustment screws, and these need to be set as you pedal and shift. Place the trike on a bucket so you can pedal the rear wheel and make these adjustments. If you have a working upright bicycle to reference, it can help to understand the functioning of the derailleurs system, and we also offer a few simple tutorials on the main page of our website.

Figure 205 shows the front derailleur being installed over the larger chain ring so that the plates can force the chain up or down to the other chain rings.

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LEVERS AND CABLES

Figure 206 – Choosing shifter and levers for your handlebars

The choices available for gear shifters and brake levers are almost endless, especially if you plan to purchase these new. There will be plenty of room on the handlebars if you have designed them like the ones shown here, and this will allow you to use just about any style lever and shifter. Obviously, the choice boils down to comfort and ergonomics, so you should set these up when sitting in your seat. Brake levers are mostly the same, and will live just under the handle grips as shown in Figure 206. Shifters on the other hand, come in all styles and shapes, so you may have to shop around your junk pile or the bicycle shop to find a set you like.

Integrated handlegrip shifters are nice as they do not take up any more space than the handlegrips. Bar end shifters may also work well here as the will not get in the way of the steering system when making tight turns. I prefer the old-school lever shifters that were common on the 1970s road bikes because I have a bucket full of them

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salvaged from scrap bikes and because they always work with no fuss. These lever shifters can be seen on my handlebars in Figure 206, and they work well in this position.

When adding all of your brake and shifter cables, take your time and avoid any tight corners as this may cause the cable to become stiff. New cables are also a good idea as they are not that expensive and will be long enough that you can trim them after a test fitting.

Figure 207 – Setting up the brakes and cables

Setting up the pad brake is quite easy - just ensure that the pad strikes the rim flat as shown in Figure 207 and set it up so that it is away from the rim enough to not rub when the lever is released. There is a small adjuster screw on the cable input to the brake lever that can be used to fine tune the brake tension as you set up the brakes and as they wear over extended use. For more information on brake basics, see the tutorials on the front page of our website.

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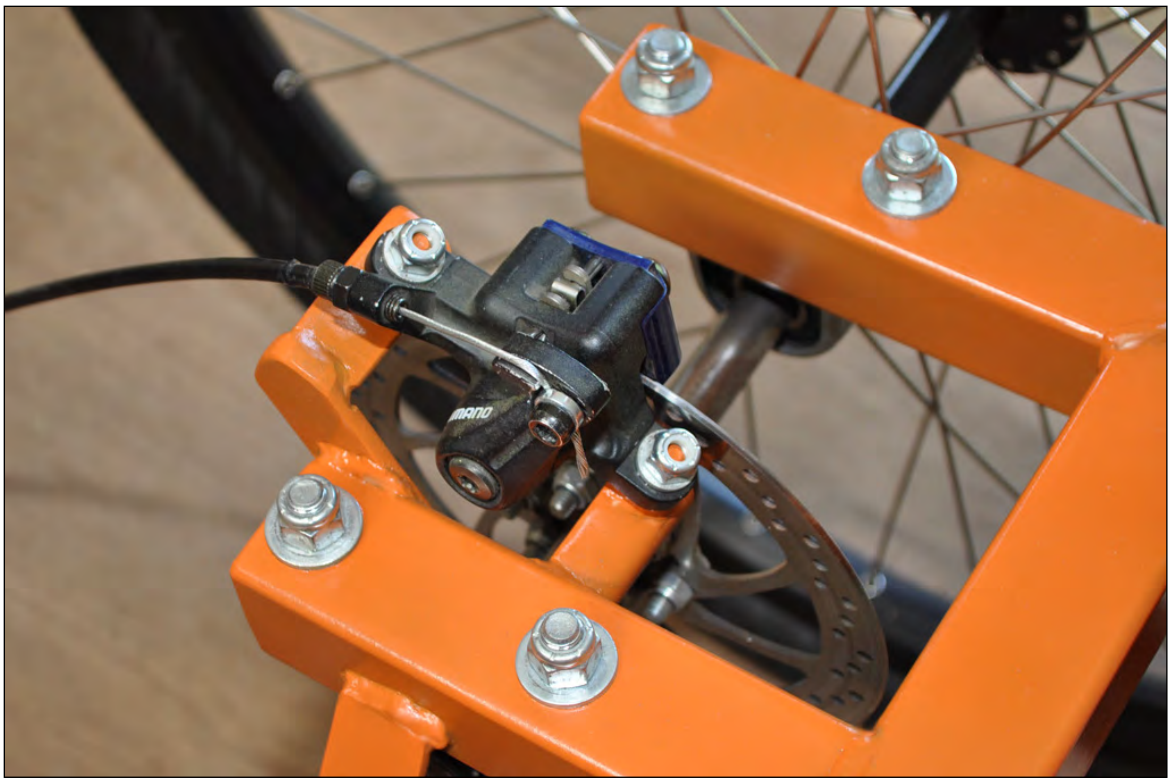

Figure 208 – Setting up the rear disc brake

The rear disc brake is setup in the same manner as the front caliper brake, keeping the tension tight but not so much that the brake rubs the disc when the lever is released. Disc brakes offer an amazing amount of stopping power, so a little slack in the lever is fine. Again, there will be a small cable tension adjuster at both the brake end of the cable as well as at the lever cable input. Figure 208 shows how the cable wraps around the activation lever on my brake.

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Figure 209 – The TimberWolf is ready for action!

Once you have your brakes and shifters working the way you want, tie up the cables around the frame using a few zip ties so that they are not flopping around or interfering with any of the moving parts. Avoid putting a tight bend in a cable, and test your installation by turning the handlebars through the full range of motion to ensure that a cable strap is not too short. With the cables setup and functional, you are now ready for that first test run.

The completed and tuned up TimberWolf (Figure 209) sits idle, ready to hit the trails.

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Figure 210 – Cargo box and rear lighting details

If you plan on riding at dusk or in the dark, it is a good idea to have a light system that can show the width of your trike as cars negotiate a path around you. I added a pair of battery operated flashing lights at each side of the rear frame as shown in Figure 210 so a vehicle approaching from the rear can see that my ride is not as narrow as a road bike. Reflectors and reflective tape are also highly effective at warning drivers that you may need that extra room on the roadway.

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Figure 211 – The completed TimberWolf in its natural environment

The completed TimberWolf is really a nice looking trike - half racing machine and half cargo trike, ready to carve up the corners in the cycle trail or simply haul back a small load of groceries from the corner store. I would offer some kind of driving lesson here, but let's face it, you just jump on a trike and put the pedal underfoot to hit the road! The only limitation on a trike like this is how fast you can zip around a corner before you may lift a wheel, and under most riding conditions, this will never be a problem. I will admit that I enjoy the odd "stunt ride", popping a tight corner so I can show off while riding on two wheels, but I wouldn't recommend you do this with a carton of eggs in the cargo box! Yes, this thing is fun.

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Figure 212 – The completed TimberWolf in its natural environment

The rear suspension really does wonders on a washboard gravel road or a city road riddled with potholes. I have several non suspension trikes as well, and the first thing I noted when travelling down the more rugged terrain was how smooth the ride was. Having the cargo box placed on the suspended part of the frame also means that your cargo gets a smooth ride along with the pilot.

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Figure 213 – Hitting the trials on the versatile TimberWolf

Although not designed as a strictly off-road vehicle, the TimberWolf does well off the road, and in low gear can effortlessly eat up hills of any size. A nice thing about climbing hills on a recumbent trike is that you can just drop into a really low gear, relax, and work your way up the hill at a slower pace without the need to balance or maintain any real speed. In the deep grass or dirt, the TimberWolf also had no problem maintaining traction in low gear and the suspension took up all but the most deep ruts and bumps in the trail.

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Figure 214 – Carry your groceries or a large battery pack in the cargo box

The cargo box has enough room for a small load of groceries or a very large battery pack for those who may want to install a front electric hub motor. The cooler worked very well as a cargo box because it was water tight, somewhat insulated and very lightweight. Swapping out the cooler for some other cargo box configuration would only involve the installation of two bolts.

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Figure 215 – The TimberWolf makes that long journey more enjoyable

Well, we hope you have as much fun riding your new trike as building it, and your cycling horizons are now wide open. With such a comfortable and agile trike, that long journey will seem so much more enjoyable, but do expect to get pulled over quite often to explain your cool ride. The surprised looks you will get when you say, “Yes, I built this” will become commonplace, and makes it all worthwhile.

If you can take a break from riding, please send a few photos of your bike our way or drop by our forum to show off your own creative modifications or cargo bay solutions!

Thanks for your support, and we hope your build progresses smoothly. With a little patience, a pile of scrap bicycle parts, and some trial and error, you can create just about any human powered vehicle imaginable.

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JOIN THE ATOMIC ZOMBIE KREW

There is plenty of room for modification on this project, so please send us your completed photos for the Builder's Gallery so that others can see what you have done.

If you need any assistance or want advice about an idea, stop by our Support Forum and introduce yourself to our many creative fellow garage hackers.

Good luck on all of your projects. Have fun and ride safely. Brad and Kathy McGowan, Atomic Zombie™ Extreme Machines

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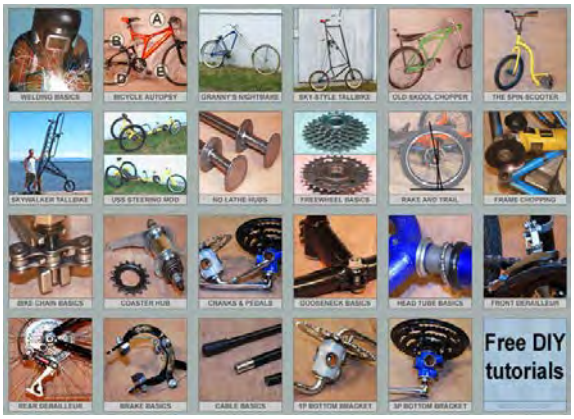

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